MAGNETICALL Aduertiſements:

OR

DIVERS PERTINENT obſeruations, and approued ex-

periments concerning the nature and pro-
perties of the Load-ſtone:

Very pleaſant for knowledge, and moſt needfull for practiſe, of trauelling, or fra-

ming of Inſtruments fit for Trauellers
both by Sea and Land.

ACT. 17. 26.

He hath made of one blood all nations of men for to dwell on the face of the earth, and hath determined the times before appointed, and the bounds of their habitation, that they ſhould ſeeke the Lord, &c.

BIBL. CANT. ACAD.

LONDON,
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TO THE RIGHT WORSHIPFVLL, DISCREET, and learned Gentleman, Sir DVDLEY DIGGES *Knight.*

SIR, the nature, powerfulneſſe, and ſtrange properties of the *loadſtone* are ſuch, that the more they are known, the more they are iuſtly admired in their moſt liuely expreſsing that infinite power, and goodnes of our God, who hath created ſo precious a Iewell for the profitable vſe of man, and for the enlarging, and ſetting forth of his owne glory. Into the ſearch of which admirable and ſecret vertues

my ſelfe by the ſpace of theſe forty yeeres, haue ſomewhat entred (as my leaſure and occaſions would ſerue, and at by times) partly by reading other mens writings, and partly by my owne induſtrie and practize: Whereby what I haue collected, and found, this little Treatiſe will ſhew. Which, whether it be any thing, or nothing, I do referre vnto the iudicious *Readers* conſideration, but in ſpecial to your fauorable conſtruction, and good acceptance.

Many yeeres ſince diuers of my good friends, and among them ſome honourable perſons, were very deſirous that I ſhould publiſh ſuch obſeruations as I had collected, both before, and alſo after the ſetting forth of D. *Gilberts* booke: And none more earneſt herein then D. *Gilbert* himſelfe, vnto whom I communicated what I had obſerued of my ſelfe, and what I had built vpon his foundation of the *Magnetiſme* of the earth. Both which hee liked well and wiſhed me to publiſh them, as I remember at the time of our priuate conference, as may further appeare by letters that I receiued from him; which I haue to ſhew vnder his owne hand.

But

But aboue all others, the perswasions of that learned honourable Gentleman, *Sir Thomas Challenor*, late Chamberlaine vnto the Mirrour of honour Prince *Henry* preuailed most with me. Vnto whom I was all the time that I attended that Prince his highnesse, for his loue and curtesie, much beholding. Whereupon about seauen yeeres since I deliuered vnto him this Treatise, finished almost as now it is, sauing some few additions vpon necessary occasions. But that Copie was either mislaied or embeseled, that he lost it; About three yeeres since he sent earnestly vnto mee for an other Copie: which also he receiued, promising me by his letters, that within three months hee would put that to the presse, and that it should be carefully and correctly performed: But what is become euen of that also I know not: Only this I am sure of that I haue met with many portraitures of my Magneticall implements, and diuers of my propositions set abroad in print in another mans name, and yet some of them not rightly vnderstood by the partie vsurping them.

Now that it hath pleased God to take

Sir Thomas Challenor and that vpon enquirie I can heare no tidings of thoſe my loſt labours, and knowing that diuers are very deſirous to ſee them, I haue once againe reuiued my ſcattered papers, collected them together, & made choice of your ſelfe to whom to entitle (according vnto our vſuall curteſies) theſe *magneticals*; your worthy ſelfe I ſay in many reſpects: Firſt, becauſe your rare learning ioin'd with ſo great pietie, accompanied with ſo pleaſing a carriage of your ſelfe towards euerie man is ſuch, as cauſeth all good men which know you, to loue you, by force of a naturall ſympathy not vnlike the appetite of concourſe & coniunction whereby our very Magnets doe affect their proper obiects. And this was verie conſpicuous in our renowned iudicious Prince *Henry*, who loued you ſingularlie well for your vertues, and delighted no leſſe to conferre with you for your knowledge in matters appertaining vnto Diſcoueries and Coſmographicall learnings, in the which his highnes was more then vulgarly skilfull.

Another is, the glorious fauour which I ſee reflected vpon you from that moſt reuerend

and

and ſingular ornament of our Church and State, reioycing in Gods bleſsing of his labors in your education : like as God hath hitherto bleſſed him in all things, and not onely my prayers and ſuch as I am who are ſo much bounden vnto him, but the praiers of many thouſands that neuer ſaw him, will not ceaſe to beſeech the Almightie long to preſerue him: and alwaies to proſper him in his godly proceedings : Wherefore this extraordinary reſpect which he hath vnto you, both is and muſt be a commanding motiue vnto mee to ſhew my good will by the beſt poore meanes that I can toward you.

Yet one more I haue, which is this : That whereas a worthy ſocietie of Gentlemen and Marchants is very highly and iuſtly commended and honoured of all men, for their great charges in their conſtant and indefatigable proceedings, for diſcoueries of vnknown paſſages to new Countries and Nations, for the further aduancement of Gods glorie, the honour of our King, and principall benefit of the whole Kingdome ; In remembring of thoſe honourable attempts, you muſt in no wiſe be

forgotten

forgotten, and eſpecially in a Treatiſe mentioning the vertues, and properties of the *Loadſtone*, being the leader and guide to theſe admirable exploits, who beſides your ſound knowledge herein, doe with great conſtancie ioine both your purſe and counſaile for the atcheiuing of them, yea and that without expectation, or hope of priuate gaine, but onely of your noble genoroſitie, knowing full well, that the aduancement of Gods glorie is abſolutely of it ſelfe the greateſt gaine with a contented minde; Wherewith, he that onely is all-and ſelfe-ſufficient, enrich you more and more in this world, and to your eternall happineſſe, moſt abundantly and perfectly ſatisfie you, by making you drinke of the riuer of his pleaſures in the world to come; Amen.

Yours with all

hearty affection

WILLIAM BARLOWE.

THE PREFACE to the Reader.

THat wonderfull propertie of the body of the whole earth, called the Magneticall vertue (most admirably found out, & as learnedly demonstrated by Doctor Gilbert Phisitian vnto our late renowned Soueraigne Queene Elizabeth of happy memory) is the very true fountaine of all Magneticall knowledge. So that although certaine properties of the Loadstone were knowne before, yet all the reasons of those properties were vtterly vnknowne, and neuer before reuealed (as I take it) vnto the sonnes of men. And although as yet many doe doubt and mistrust that the earth it selfe hath no such vertue, I doe nothing wonder at it, because before I read his learned workes, and had tried many of his experiments with mine owne hands, and had conferred with great Trauellers, and perused the obseruations of our chiefest Nauigators both for their variations, and declinations, I neuer beleeued it my selfe. But this I may truely affirme that searching with diligence his first fiue bookes, and making triall of all those propositions which I iudged to be of importance, I alwaies found the maine drift, touching this point, certaine, constant, and agreeable to the diligent obseruations of diuers men of experience; although in some other

matters of the Loadstone *his experiments and mine did sometimes disagree, as I signified to himselfe in his life time, which he did take in very good part, as I haue yet his owne letters to shew. But concerning his sixth Booke entreating of the motion of the earth, I thinke there is no man liuing farther from beleeuing it, than my selfe, being nothing at all perswaded thereunto, by the reasons of other men, which he alledgeth, and as little or lesse (if it were possible) by those his inuentions, endeauouring to proue the motion of the earth by the earthes* Magneticall *force and vertue.*

Amicus Socrates, Amicus Plato, sed magis amica veritas *is the onely cause why I doe embrace his iudgment, in the one, and refuse it in the other, in matters of this nature following this Rule:*

Nullius addictus iurare in verba Magistri.

But to returne to the Magnetisme *of the whole earth, I doe hold it to be one of the rarest, and excellentest inventions, and the best followed by him, with euident proofes and of the greatest consequence for the admirable art of Nauigation that euer was found out since the Creation of the world, so that it may well be said of him touching that point.*

Exegit monumentum ære perennius
Regaliq; situ pyramidũ altius, *in respect of the manifold vse and commoditie thereof in the doings of this life. The properties of the* Magnet *serning not onely for Sea-affaires, but also for trauelling by Land in waste and solitarie deserts, for moueable Sun-dyalls in all places of the world, for the more ready and exact Chorographie of any Countrey, or the true plotting of any ground, and for the following of any Minerall veyne that is voide of Iron vnder the earth, for Pioners and diggers in Mines.*

And

And in all this appeareth the wonderfull power and goodnes of God who hath vouchsafed to reueale vnto the weake knowledge of man now towards the end of the world, his admirable treasure, before vnknowne, of his powerfull Creation, by effect so plaine vnto the meaneſt capacitie: And that out of a baſe, contemptible and dead creature, as it ſeemeth to be, and yet filled with ſuch excellent and wonderfull vertue, that all the Gemms of the world, haue not the like; neither if it were wanting could ſupply the want thereof, or countervaile the benefit that it bringeth to the life of man.

Claudianus *(a famous Poet) well nere twelue hundred yeares ſince, ſaith as much in commendation of the* Magnete, *when as yet the Sereditical or Iron-drawing property thereof was onely knowne.*

—— Lapis eſt cognomine Magnes
Decolor, obſcurus, vilis &c.

And againe,

Sed noua ſi nigri videas miracula ſaxi,
Tunc ſuperat pulchros cultus, & quicquid Eoïs
Indus littoribus rubra ſcrutatur in algâ.

But what would he not haue ſaid, had hee ſeene the true cloſſet indeed of all Magneticall *miracles vnlocked, and in glorious manner ſet wide open as now it is at this day.*

Many of our Nation both Gentlemen and others of excellent witts and louers of theſe knowledges, not able to read Doctor Gilberts *Booke in Latin, haue bin (euer ſince the firſt publiſhing thereof) exceeding deſirous to haue it tranſlated into Engliſh, but hitherto no man hath done it, neither (to my knowledge) as yet goeth about any ſuch matter, whereof one principall cauſe is that there are very few*

that vnderſtand his Booke, becauſe they haue not Loadſtones *of diuers formes, but eſpecially round ones: Alſo ſuch verſory needles fitly framed, and artificially placed vpon their pins, and other ſuch implements, as he doth there preſcribe, wherewith being furniſhed, as they read his propoſitions in words, they might ſtill ſee the truth of them in the things themſelues, according as himſelfe forewarneth that theſe skills muſt be learned* Ex rebus ipſis non ſolum ex libris, *out of the things themſelues and not onely out of Bookes. A ſecond cauſe may be for that there are diuers words of Art in the whole courſe of this booke proper to this ſubiect, and fit to the explanation of his figures and diagrammes which cannot be vnderſtood but by the helpe of the* Mathematicks, *and good trauelling in the* Magneticall *practiſe.*

Moreouer his alleadging of other mens erroneous opinions concerning this Argument, and his confutations thereof, may ſeeme at the firſt to a yong beginner ſomewhat harſh and tedious. Both which I ſuppoſe in the Engliſh tranſlation (if any were) might well be omitted: like as in this my Treatiſe I thinke it not altogether ſo pertinent to handle them all.

And a ſport it is to behold diuers of ſmart witts, and ſuch as weene themſelues to be ſo great Clerkes, that they will aduenture boldly to diſpute de omni ſcibili, *how miſerably they runne their witts on ground, when onely by a ſlender reading ouer of his booke, or moſt commonly ſome part thereof, they will take vpon them to define, controule, and diſcourſe of thoſe matters fearing nothing more than that of the Poet,*

—— mihi turpe relinqui eſt
Et quod non didici ſane neſcire fateri.

For

For being vrged by diuers of our Gentlemen (among whom these knowledges are had now a daies in some request) somewhat they must speake, which must be either superciliously to scorne such things, as vanities, because themselues vnderstand them not, or else with slender ostentation to blunder out their masked ignorance, supposing it to be inough for them to say that they haue read Dr. Gilberts *Booke, and so to vse that for a* Supersedeas *to acquite them of any farther inquirie. But many, being now at length weary to take such counterfeit shewes for good payment, doe seriously seeke to haue some sound knowledge of the things themselues, and not to depend vpon other mens extrauagant disputes, but to be their owne iudges in matters that concerne themselues, and are subiect to their owne senses and reasons, and especially because some of them must aduenture their whole estates, yea and also their liues vpon the right vnderstanding of some* Magneticall *conclusions.*

Wherefore vpon the earnest longing of certaine mine Honorable and Worshipfull freinds, and for the singular loue that I beare to the louers and practizers of the worthy Art of Nauigation, and to satisfie the commendable desires of such as like to haue some insight (though themselues be not practizers in these matters of admirable knowledge, and great vtilitie) I haue vndertaken to contriue all the cheifest points of this most necessary skill, and the vse of them in this short Treatise.

Not meaning to translate Doctor Gilberts *booke, but to take those thing out of it which I shall thinke fit for this purpose, which are onely the* Magnetisme *of the whole earth, and some of the consequents thereof, and to adde the rest of mine own industry: Wherin I may be bold after a*

ſort to challenge a right, as hauing endeuoured to get ſome inſight in this argument (a matter well knowne to diuers) aboue the ſpace of twenty yeares ere Doctor Gilberts *booke ſaw light. And in very deed I communicated many of my obſeruations with him, aboue one whole yeare before he put it out in print. To be ſhort, of all that I ſhall ſet downe in this Treatiſe my requeſt is, that the Reader will admit nothing but that which ſhall be confirmed by good reaſon, or vndoubted experiments. And I purpoſe (God willing) to tye my ſelfe, as ſtrictly vnto this rule as euer any man did that hath written of the like argument, making it euen a matter of conſcienae to deliuer any thing herein for certaintie, that my ſelfe ſhall not know to be ſound. And ſo by this meanes ſhall I neither abuſe the Reader with any vntrue aſſertion, nor iniurie ſo certaine and ſo excellent a knowledge with any doubtfull or vnapproueable concluſions.*

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CHAP. I.

MAGNETICALL
Aduertiſements.

CHAP. I.
Of the magneticall power and force of the whole Globe of the Earth.

Onterning the Magneticall force of the whole body of the Earth, I haue ſelected theſe experiments to proue it.

Take any peece of ſolid earth that hath ſome toughneſſe to hold together, and will abide the fire, as any ſort of clay, or bricke (which ſomtimes was clay) faſhion it in ſuch manner that it bee vniformely extended towards both ends (the Ouall or long figure is fitteſt for our purpoſe) put it into a fire of charcoles, increaſing the heat by little and little, and at the length with often blowing, make it throughly as red hot as you can: let

it remaine ſo for the ſpace of halfe an houre, or more, that thereby all ſuperfluous moiſture may be conſumed, and aduerſe qualities ſeparated from it, then take it forth, and let it coole of it ſelfe, being firſt ſet *North* and *South*, with either end anſwerable to the variation of the place, not paralell vnto the *Horizon*, but eleuated anſwerable to the *Latitude* as nere as you can. Certaine it is that this peece of earth thus ordered, will ſenſibly ſhew you that it hath true *Magneticall* vertue. But here before I proceed any farther I muſt deliuer vnto you a neceſſary obſeruation: There are two kindes of *Attractions* (as they are commonly called) the one *Magneticall*, the other *Electricall*. The *Magneticall* hath alwaies ſpeciall reſpect vnto the *North & South* points of the *Magnet* or *Magneticall* body. The *Electricall* body hath no manner of reſpect vnto any one point of the *Electricall* body, more than another: And by this difference theſe two kinds of *Attractions* are eaſily diſcerned; As alſo by this, looke what end of the *Magneticall* needle the one end of the *Magnet* doth draw, the other will chaſe away; but the *Electricall* body draweth alike at all ends. And thirdly after this ſort, lapp this *Electricall* body in a paper and it will draw nothing at all, but interpoſition of braſſe or of a ſtone wall within the orbe of the *Magnets* vertue, doth nothing weaken the ſame, or hinder his effect towards his peculiar obiect. Notwithſtanding (to ſpeake properly) *Attraction* pertaineth onely to *Electricall* bodies, becauſe the whole *attractiue* vertue is onely in the *Electricall* body it ſelfe, and nothing at all in the thing that is attracted. The *Attraction*

(com-

(commonly ſo called) of the *Loadſtone* is rightly to be termed, *Concurſion*, *Confluence*, or *Coition*, becauſe it is the running or vigorous meeting together of two *Magneticall* bodies hauing a mutuall inclination the one to ioyne with the other, or by any other name, bearing like ſenſe. For the true knowledge thereof, being but lately as a ſtranger arriued amongſt vs, common vſe (*Quem penes arbitrium eſt, & ius & norma loquendi.*) hath as yet ſcant ſuted it, with a conuenient name to expreſſe this property; So that *Magneticall Concurſion* is neuer but betweene two bodies, ſuch as both of them are *Magneticall*; As of one *Loadſtone* with another, or of a *Loadſtone* with yron or ſteele, or yron oare if it be prepared, or betweene two peeces of yron or ſteele that are reuiued with a *Loadſtone*; for indeed the *Loadſtone* can but reuiue, and multiply *Magneticall* force in a body that naturally hath it in ſome meaſure before: but cannot infuſe it into any thing, that before is vtterly voide of it, as of mettals, in yron or ſteele, and not in gold, ſiluer, braſſe, &c. *Electrum* in this argument is named that which is either *Amber* in ſubſtance, or at the leaſt of the quality, and that *Amber*, being rubbed, hath, to take vp moats, feathers, ſtrawes, ſticks, and other ſmall things. The which property is alſo in ieate, brimſtome, hard waxe, (if it be ſmooth) and in infinite other things both naturall and compound: all which becauſe of that qualitie in this argument are termed *Electricall bodies*, and their taking vp of things is called *Electricall attraction*, hauing onely a ſlender reſemblance, and no truth of the *Magneticall* qualitie.

But that aboue-mentioned peece of earth, prepared in such sort as is before prescribed, will by *Magneticall concursion* shew it selfe to be a true *Magneticall* body. For the one end of the *Magneticall* needle will couet towards the one of the prepared masse, and flie from the other. And contrariwise also, though it will do both but weakely, not with power comparable to a naturall *Loadstone*, yet as truely as that. That end which cooled toward the *South*, will draw the true *North* end of the needle, and that end which cooled toward the *North* will draw the true *South* end of the needle. If so be as yet you will haue another infallible argument, doe thus: Marke what end draweth the *North* end of the needle, afterward put the new made *Magnet* into the fire againe, and when it hath been glowing for the space of halfe a quarter of an houre, take it out and coole it being placed with that marked end toward the *North*, most assuredly that end now will draw the *South* end of the needle, & the *North* end of the needle will shun it, which before approached vnto it. The reason here of is, because the fire hauing abolished all the former *Magneticall* qualitie of that masse wherewith it was in a contrary position affected in the former cooling, now leaueth it apt and fit to receiue any other new impression: which presently it taketh againe either regularly, if in the cooling it be placed with the ends to the *North* and *South*, or (if it be placed otherwise) confusedly, by the *Magneticall* force and vertue of the whole body of the earth, by regular and confused, this is the meaning. Take any lump of earth, or any brick-bat ordered in this sort, certaine

taine it is that this lumpe of earth or bricke-bat hath ſome *magneticall* vertue therein, yet ſo feeble and weake, that our ſence cannot diſcerne it, becauſe of the vnfitneſſe of the forme, and the confuſed diſperſion of that weake force, through the whole body thereof. Then ſuppoſe you will bring either of theſe into an extended ovall forme, which is moſt apt (as before I ſaid) for any body *magneticall* to ſhew his force, yet this will helpe it nothing at all of it ſelfe, as you may eaſily make experience in euery *Loadſtone*. For if you take a *loadſtone* of a confuſed forme, it is not inough to bring it into a conuenient ovall, except with diligence you reſerue the points of the North and South in the two ends thereof, for if you leaue the points in the ſides you marre it with this ovall forme. For the ſtone will not lightly be of one quarter of the force, it was of before; For the ovall forme giueth it no vertue, but is the fitteſt for it to ſhew the vttermoſt of that ſtrength, which of it ſelfe it had before, if you obſerue the due points, and not otherwiſe. But in this earth and bricke it is not poſſible to finde the due points in ſuch ſort as you may in a *Loadſtone*, becauſe of the weakneſſe of the *magneticall* force therein contained. And therefore you cannot bring that into a regular ovall forme, to haue the due points in the very ends. But if you firſt make it into an ovall forme, and by the fire take away the confuſed *magneticall* force, and all other peruerſe qualities thereof, that being by nature a *magneticall* body in his cooling before ſpecified, receiueth preſently by that vnreſiſtable power of the earth, his *magneticall* vertue, according

vnto that forme, and will regularly haue his due points preciſely in the ends, without any confuſion. *Iohannes Baptiſta Porta Neapolitanus*, writeth that hee did make triall of the way that *Paracelſus* hath ſet downe for to increaſe the vertue of a *magnet*, namely to heate him red hot in the fire, and to quench him in the oyle of *Crocus Martis* : And *Baptiſta Porta* ſaith, that hee found it a deteſtable falſhood. For ſaith hee, he is ſo farre from increaſing his vertue, as that (being once red hot) he looſeth all his own, paſt all recouery. But for all this that hee ſaith, I doubt whether *Paracelſus* be iuſtly reproued or not, for by mine owne experience I know that the heating of a *Loadſtone* vntill he be red hotte doth weaken a *loadſtone*, but taketh not away all his force, and in my triall hereof I found a very manifeſt proofe of the *magnetiſme* of the earth, which I thought neceſſary for to inſert in this place. I haue made this triall of Fragments of *magnets* of diuers kindes, and alſo of diuers kindes of Iron Mines which are next in degree vnto *magnets*, namely after this ſort. Heate him in the fire by little and little (for feare of breaking) vntill he be red hotte, then take him out and let him coole, then marke (with chalke or what you pleaſe) thoſe parts that reſpect the North and South and you ſhall finde thoſe marked places, the North, and South Poles of the *Magnet* : put him into the fire againe, vntill he be red hotte, and coole him contrarily, and you ſhall haue the contrary effect. Therefore if *Baptiſta Porta* did make his triall with a *Loadſtone* very long in forme, and chaunced (for Maſter *D. Gilberts* miſtery of the Earths *magnetiſme*, was not

then

then reuealed) for to coole him in his oyle of *Crocus Martis* with his ends Eaſt and Weſt, the axis of the ſtone being then ouerthwart in the middle, it were no maruell if he found no force in the ends. And I do not thinke it improbable, but that *Paracelſus* way may doe ſome good rightly vſed. Doctour *Gilbert* writeth that ſome Iron mine, will affect a *magneticall* needle, as it is of it ſelfe, being vnprepared by fire: but as yet I neuer could finde any ſuch, but this I haue often tried, that it being of no manner of *magneticall* vertue of it ſelfe no more then a flintſtone vnprepared by fire, being made red hott, and cooled, is preſently impregnated with very apparant *magneticall* vertue, according to the ſcituation that hee is cooled in, and although you heate and coole him often, and diuers waies, he will ſtill keepe his vertue, according to the ſcituations, of his cooling. And ſome Iron Mines I haue found, which being but in this ſort prepared haue had as ſtrong force as ſome naturall *magnets* haue had. It is the goodneſſe of the *Loadſtone* ioyned with a fit forme that will ſhew great force. For as a very good forme with baſe ſubſtance can doe but very litle, ſo the ſubſtance of the *Loadſtone* bee it neuer ſo excellent, except it haue ſome conuenient forme, is not auaileable. For example, an excellent *loadſtone* of a pound waight and of a good faſhion, being vſed artificially, may take vp foure pounds of Iron; beate it into ſmall pouder, and it ſhall bee of no force to take vp one ounce of Iron; yea I am very well aſſured that halfe an ounce of a *Loadſtone* of good faſhion, and of like vertue will take vp more then that pound will doe

being

being beaten into powder. Whence, (to adde this by the way) it appeareth manifestly, that it is a great error of those Phisitions and Surgeons, which to remedy ruptures, doe prescribe vnto their Patients to take the pouder of a *Loadstone* inwardly, and the small filing of iron mingled in some plaister outwardly: supposing that herein the *magneticall* drawing should doe great wonders. Whereas they consider not that the stone being dissolued into powder, euery little particle of the dust hath two points contrarie, the one drawing to, the other repelling and putting from: and so being thus confounded by a contrarie working doth much more harme, then good with his *magneticall* quality. As for the astringent, and drying properties of the *Loadstone* I leaue them to the diligent obseruation and iudgment of the skilfull in phisicke. But to returne to our purpose, and to alledge this also, besides the former manifest proofe, if the earth were not by nature a *magneticall* body, the afore mentioned peice of earth could not receiue from a *Loadstone* any *magneticall* power: But most certaine it is, and by many vndoubted experiments confirmed, that it will euidently receiue *magneticall* power, from a *Loadstone*: therefore it is manifest that the earth is by nature a *magneticall* body. Furthermore, as among all the mettals iron doth incomparably more resembie the earth in substance then any other doth, it likewise doth more participate with the earth in quality, and principally in the *magneticall* peculiar property hereof, as notorious experience declareth, yea euery peice of iron Oare, being naturally (as D. *Gilbert*

sheweth

ſheweth) a *magnet*, although of feeble forte, and all *magnets* being a kinde of iron Oare, is the very cauſe, that onely iron or ſteele, and no other mettall is capable of that vertue, namely to haue that reuiued, and multiplied by the vicinity of a *magnet*, which at the firſt in ſome meaſure, was originall in it ſelfe, as it is aforeſaid; It is alſo well knowne, that the *magnet* is a Stone moſt commonly of inuincible hardneſſe, nothing inferiour to any iron or ſteele of the excellenteſt ſort, notwithſtanding ſometimes wee ſee of them that are nothing, but a dry lumpe of earth, and yet of thoſe alſo ſome ſtronger in vertue, then diuers of the hard ſtony ones are: Which earthly *magnets* if a man aſſay to bring it into a faſhion by grinding on a grinding ſtone (according to the common vſe) they will conſume into very mudde in the water. Now (to drawe towards an end of this matter) albeit the *magneticall* vertue be moſt eminent in the *magnet*, as in the preciſe and perfect ſubiect thereof: yet is the ſelfe ſame quality, in a meaner degree, euidently to be diſcerned in euery peice of earth, prepared and ordered (as is aforeſaid) yea although it be not cooled with his ends North and South, that it may take his *magneticall* force from the vertue of the earth, for if you coole it with his ends but Eaſt and Weſt and ſet two *Loadſtones* in the cooling, the one at one end and the other at the other end, it will receiue a ſenſible and apparant *magneticall* vertue according to thoſe points of the *Loadſtone* that were applied vnto it, namely that end which was next the South point of the *Loadſtone* will haue a North properly, and that end that was next the North

point, will haue a South property: yea if you set the North part of two *loadstones* vnto each end, both ends of this new made *magnet* will haue a South property; And contrariwise if you apply the South ends of two *magnets*, both his ends will haue a North property; And those properties before mentioned will shew themselues to be *magneticall*, because whether end of this new *magnet* draweth any one end of a *magneticall* needle, the same will chase away the other: which is proper only vnto *magnets*, and *magnetical* bodies. After the like sort, only by application of two strong *loadstones* by the space of 24. houres you may alter the points of any base *loadstone*, which you would, and make them both North or South as you please: so that the *loadstone* which you would alter be but base in qualitie, and not great in substance, and that the other be of a reasonable bignes, and good strength. And this vertue by such application of two *loadstones* I haue often found effectuall in new bricke lately taken from the kill without any farther putting into the fire at all; And although it be against the nature of a *loadstone* to haue both his ends naturally of one vertue, that is to say, both of them of a North property, or both of them of a South property: yet here it is to be vnderstood, that it is the forcible violence of the strong ones, being applied iointly vnto each end of the weake, that doe chase the contrarie property of the weake one into the middle thereof: And therefore if you diuide this weak one in the middle, then both those ends, which being ioyned together were the middle, (where no *loadstone* can shew any vertue) being now disioyned,

ed, and become ends, will presently shew a contrary property (according vnto *magneticall* nature) vnto the other two ends.

CHAP. II.

The ambiguity of the North and South ends of Magnets and Magneticall bodies explained, and Doct. or Gilbert *therein defended.*

THere is not any one errour that breedeth a greater confusion in *magneticall* knowledge, then the mistaking of the right vnderstanding of the true North and South ends, aswell in *magnets* themselues, as also in *magneticall* bodies, whosoeuer therefore that will take a little paines in the beginning for to vnderstand this well, shall free himselfe from many intricate difficulties in this argument, which otherwise must needes befall him; wherein some hauing limed themselues, haue fallen into many errors, euery one still begetting another worse then himselfe. All those which did write before Doctor *Gilbert* did name that end of a *magnet* which being placed in a wooden dish, and set to swimme in water, would turne and settle it selfe towards the North, the North end of the *magnet*; and the other the South end. And euen so did they of all Dial-needles, Compasses and *magneticall* bodies. But Doctour *Gilbert*, not for any new-fangled innouation, or selfe-conceit, but vpon good reason and firme demonstration auoucheth and prooueth the contrarie, and clearely sheweth, that the former vulgar assertion

seriously defended, tendeth vnto the ouerthrow of all *magneticall* Philosophie, by vndermining (as it were) the whole frame thereof; and yet in common speech the old rule may hold, *Loquendum cum vulgo sentiendum cum sapientibus.* For it would seeme a strange speech vnto a Marriner to tell him that his Flower de luce were become the South point of his compasse, and yet this assertion is most true, and certaine that it is the North end of euery *magnet* and *magneticall* body, that being placed in a thinne wodden dish in water, or any *magneticall* needle vpon his pinne, which setteth it selfe and pointeth vnto the South, and it is the South end which pointeth vnto the North. For proofe hereof, take these wordes of North and South in whether of the two former significations you please, and make triall thereof in any two *magnets*, or any two *magneticall* bodies, so placed that they may freely turne according vnto their natures, and you shall alwaies see a naturall inclination of the contrary ends of the one vnto the contrary ends of the other, as of the North end of the one vnto the South end of the other, and reciprocated of the South of the one to the North of the other; But the ends in the one and the other will alwaies flie from those of like denomination, as the North end of the one from the North end of the other, and the South end of the one from the South end of the other.

reciprocally

For as much then as all *magnets* themselues, and all *magneticall* bodies (being so placed as they may haue their free motion) compose themselues *magnetically* towards the Poles of the earth, it must needs be that

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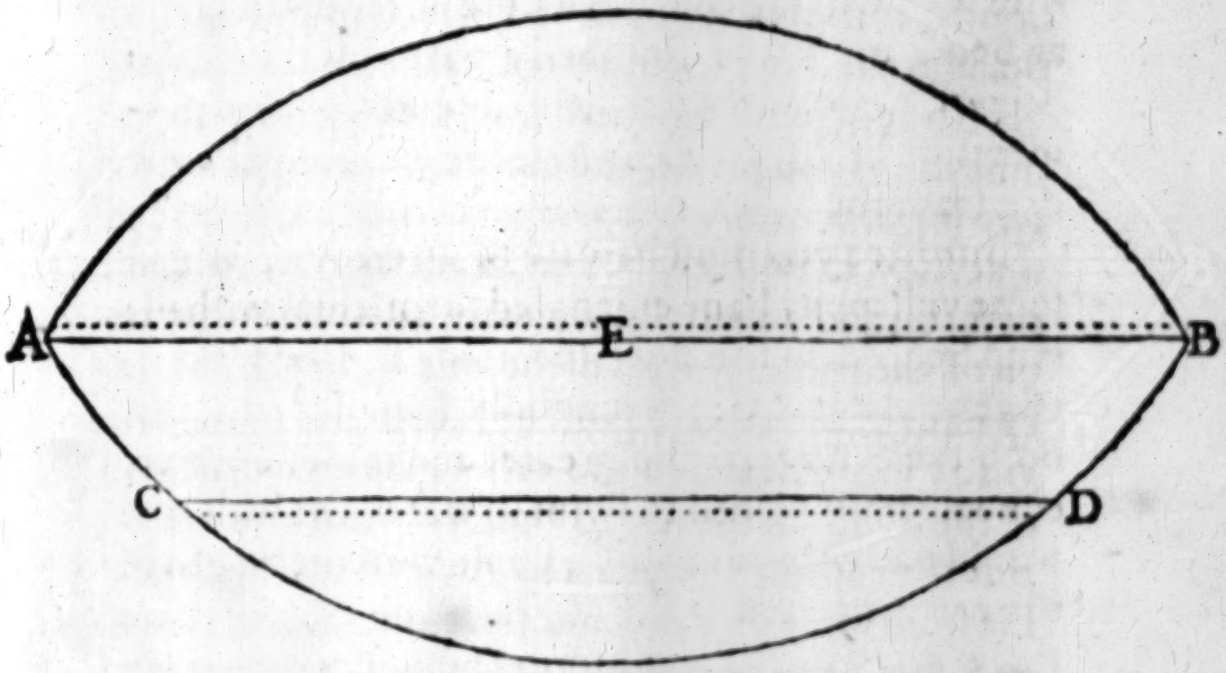
it is the true naturall South end of the *Magnet* or *Magneticall* needle, that pointeth towards the North of the Earth: and it is the true naturall North end of the *Magnet* or *Magneticall* needle that pointeth towards the South of the Earth, becauſe the contrary ends doe affect one an other, and each of them doe naturally flie, the one end of the one, from that end of the other, which is of like denomination vnto it ſelfe: for example, In this following *Diagram* of the whole *Magnet*, E. A, is ſuppoſed to note the true naturall North end thereof, and B. the South end.



This *Magnet* being placed in a woodden diſh, ſwimming in water, freely muſt, and will, of Magneticall neceſſitie, with his true North end, A. ſettle himſelf ſo, that A. muſt point towards the South of the Earth. And the South end, B. towards the North

of the Earth: Becauſe all Magnets and all Magneticall bodies, do naturally affect, the one the contrary end of the other, and doe auoide and flie from their ends of like denomination.

Now for a further conſideration of theſe properties ſuppoſe that you will cut of a peece of this *Magnet* meridionally, viz. C. D: manifeſt experience will ſhew, that C, which did in nature participate with A. in the entire *Magnet*, E: (as being both of the true North part thereof) now being ſeparated, will not abide it. In like manner D, of the other end of the little one, will not abide, B: of the great one, with whom being entire in nature he did participate, as being both true Southerly parts of the entire *Magnet*, E: And that becauſe the ends of like denomination of any two *Magnets*, doe naturally flie the one from the other.

But here you muſt beware of an errour, which ſome vnhappily haue entangled themſelues withall: who beholding the afore-mentioned diſcord (as betweene A: and C:) wrongfully ſuppoſed, that, if both theſe *Magnets* the greater and the leſſe, were conueniently placed to ſwim in water the little one would not with his end C, point vnto the South of the earth, as it did in the *Magnet* being entire; where it was a part of the true North end, but would point quite contrarily. There is no manner of any ſuch alteration, but that both the great one and the little one (and all the like, that are cut meridionally one from another) will abſolutely point the very ſame way which the entire one did, only you muſt know, that the meridian Line will ſomewhat be remoued

in

in each of them from the diuision, as you may gesse by the two pricked lines, parallel vnto the meridian (or axi) A: B: of E. the entire one, and the disagreing of their ends is onely within the *Orbe* of their forces, both their generall d spositions towards the Earth euer continuing one and the selfe-same that it was at the first. Yea moreouer, place them so that they may freely swim within the orbe of their owne force, and they will (with very little helpe or none at all) conforme themselues in such sort that the one of them will ioyne it selfe endlong vnto the other, at their contrary ends, and point the same way both of them, the which they did at the first in the entire one. If you touch the end of any *Magneticall* needle vpon A, being the true North end of that *Magnet*, that end of the needle will become a true South end, and will point vnto the North of the *Horizon*: if you touch it vpon B, that will become a true North end, and will point vnto the South of the *Horizon*. And the like will it doe, if you touch it vpon, C: as when you touched it vpon, A, and vpon, D, as when you touched it vpon B, although in both these not so strongly; so that *Doct: Gilberts* assertion doth not gaine-say the Marriners opinion, that his *Flower de Luce* should not still remaine the North point of his Compasse, onely hee sheweth which end of the *Magnet* it is, which doth giue him that vertue, namely, that it is the true North end; so that if you hold the true North end of the *Magnet* neere vnto the *Flower de Luce* it will come vnto him: if you take away the *Magnet*, it will come vnto the North of the

Horizon.

Horizon. If you will diuide a *Magnet* not meridionally as in the former example, but

æquinoctially, as in this by the pricked line, C: D. A. being still the true North end, and B: the true South end, and A: B: being the Meridian line, or axis of the stone: if you set these diuided seuerall peeces a sunder, that they may swim within the *Orbe* of their forces, they will affect to ioyne themselues in the very place where they were diuided, as also in the ends, A: vnto B: by the former reasons of contrary denomination. And if you place them a swimming without the *Orbe* of their forces, A: and B: will still yet retaine their former natures, and euen so will it fall out, if you make your diuision in any other place of the *Magnet* towards either end parallell vnto æquinoctiall of the *Magnet*.

Chap. III.

Certaine generall obseruations of the nature and properties of the Loadstone.

Loadstones of diuers and sundry parts of the world as of *Norway*, *Elva*, *Bengala*, &c. haue one and the selfe same property directiue, I meane of shew-

ing

ing the North and South, and also the selfe-same points respectiue declining or dipping vnder the *Horizon*. They doe likewise agree in their variations, and each one will draw yron, and likewise one another. Euery *Loadstone*, of what forme soeuer he be, hath either actually or potentially two points, the one Northern, the other Southerne. Actually, if either by casualty (if it so fall out) or by industry the stone be so fashioned, that those two opposite points be eminent or perspicuous therein: Potentially, if that either the stone be flat and but thin in the dimension of North and South though broad otherwise, for so shall the vertue of the stone be dispersed to the extreame parts thereof, in the edges round about; or if it haue the two opposite points in any concauitie, then will the stone shew in the eminent border or edge of that concauitie onely a confused dull force, and in the concauitie it selfe very little or nothing at all. That stone is well proportioned for touching which resembleth an *Ouall* forme, and hath his due points in his ends, and is voide of any bunch or concauitie. For the generall forme of a stone being good, euery concauitie is a diminishing of his force, and euery bunch is but a superfluous burden; Insomuch that my selfe haue made experience of a stone that of substance was very good, and of weight was vpon a three and twenty ounces, but of a disordered forme, I therefore tooke away twelue ounces from him, and yet diminished not one iote of his force. And this did I in a stone that was all of like substance. But if it be one that is intermingled of diuers substances (as many such there are and those

easily discerned by their colour) you may somtimes take away three quarters and more of his substance without diminishing any thing at all of his vertue. For colours, most commonly the Iron-like is best: very blacke or whitish seldome proues good; gray, indifferent; the more white in any stone, so much the worse. There are certaine that are of an yron colour, mingled with red, of which some bee very good, some but indifferent. By three waies you may proue whether a *Magnet* be good or not; the one is, by taking vp yron with the bare stone: The other by giuing more or lesse vertue vnto a knife, or any such thing to lift yron: The third if it will with good strength moue a *Magneticall* needle a pretty good distance of, and readily alter the ends of the needle without touching of them, making the North South, and the South North: The two latter of these doe neuer faile, but the first doth diuers times. And very certaine it is, that whatsoeuer stone doth most strongly impart his force vnto a knife, or moue a needle with quicknes, the power of lifting vp yron in such a one, will mightily be increased with a Cap. For this is generally the nature of all *Magnets*, that if there be 2. of different quantities, and equall strength in lifting vp yron, the greater will giue the stronger touch, and moue a *Magneticall* needle farther of, although the lesser will take vp as much yron, or somewhat more, than the greater. And againe suppose there be a *Magnet* of a pound weight, that being fitly armed, will take vp foure pounds of yron, and not aboue, if you diuide him into very small peeces, you shall finde of them being orderly vsed that will lift

vp

vp 20 times, yea 40 times his owne weight and a great deale more, if they be made very ſmall, as of three or foure graines weight; And yet where the great one will giue a touch vnto a knife for to take vp foure ounces of yron, and will moue a *Magneticall needle* three foote of; this little one will not giue a touch vnto a knife to take vp a needle, nor moue a *Magneticall needle* foure inches of; that as a *Magnet* is diminiſhed in ſubſtance (I meane a *Magnet* of a regular forme) ſo doth he looſe in his vertue of touching, and increaſeth for his ſmall quantitie in lifting of yron, whereby it is manifeſt that theſe two properties goe not alwaies ioyntly together in the ſame proportion and degree. And here hence it is, that many ſeeing little *Magnets* artificially ſet in rings for to take vp (for their quantitie) a great peece of yron, doe wrongfully imagine that the great one (whoſe particles they are) or any other great one, ſhould doe the like, namely to take vp ſo many times their owne weights. Alſo very often it is ſeene, that *Magnets* being of like forme and weight, but of diuers kinds, the one will take vp more yron of himſelfe without the capp, and yet the other giue a farre ſtronger touch; but then, if you doe fit both of them accordingly with caps, he which gaue the ſtronger touch, will take vp more yron than the other. The principall force of the *Loadſtone* well proportioned, paſſeth in a direct line, from the middle of his ſubſtance, being (as it were) a Center, through his two ends or points, which are the imaginarie lines of his chiefeſt force, from which Center, there iſſue infinite others alſo through all parts of the *Superficies* of the ſtone,

on either ſide, betweene the two extreame points and the middle, all which on either ſide of the middle, being of one nature and property in reſpect of their touch are exceedingly different in ſtrength. For that ſtill waxeth leſſe and leſſe, as it approacheth continually nearer and nearer the middle, where at length in the middle, betweene the two ends, it vtterly fainteth and commeth to nothing. The *Loadſtone* communicateth his property to the yron or ſteele that is touched with it, ſo farre forth, as the yron, or ſteele, which is touched, hath habilitie to receiue, and ſo that good skill in the touching be obſerued, ſteele is farre better than yron, and receiueth a farre ſtronger touch, and much more effectuall. The purer ſteele, ſo much the better; and if it bee yron, the purer likewiſe, the better, alwaies regarding that both of them be very ſmooth, and cleane, and haue their due temper. The principall property in common vſe is the ſhewing of *North* and *South* in the *Horizon*, with the appendants therevnto belonging, which is much more apparant, more ſtrong, and more commodious in the iron and ſteele, that is touched, than it is in the ſtone it ſelfe, becauſe the ſubſtance of them may be filed and cut away, and drawne into any forme, that we like or liſt our ſelues, which the ſubſtance of the ſtone will not permit. The *Magnet* is of ſuch nature, that euery peece broken of and ſeparated from the whole, hath all the properties of the whole, the ſame ſeuerall points of North and South, and habilitie alſo for the touch, like in kinde, though not of equall power, according to the quantitie and proportion of the peece, and the

part

part of the stone that it is taken from, and this propertie in a meaner sort hath the touched needle and wyar of a Compasse also.

Chap. IIII.

By what meanes the chiefe points of any Magnet of what forme soeuer may easily be found out.

MAke a respectiue or declinatorie needle, of an inch or thereabouts in length and giuing him his touch, fasten him by his *Axis* vpon a little forked sticke, or any such thing, that the needle may haue free scope, then offer the stone neere the needle, turning it round about, and immediately you shall see the North of the needle (as it is as yet commonly called, because it pointeth vnto the North) point directly vnto the true North end of the stone as soon as it commeth neere vnto it, and as you turne away the end of the stone the needle will point still somewhat towards it, till the South end of the stone approacheth, for then will the needle wheele about vpon his *Axis*, and point directly with his South, and to the true South of the stone. But if you hold the needle neere the stone, in such sort that it cannot turne about at liberty then the force of the stone may soone change the properties of the ends of the needle, that the one point which was North shall become South, and that the other which was South shall become North, yet the thing it selfe is easily discerned: For the Northerly end will alwaies hang lower.

And whereſoeuer the needle, being held neerer vnto the ſtone doth ſtand parrallell vnto it not inclining with either end, towards the ſtone there directly, vnder the middle of the needle, the North and South properties of the ſtone doe diuide and part themſelues. This matter is much better performed, with a ſmal narrow *loadſtone* of halfe an inch (more or leſſe) in length, hauing in the ends his due points of North and South and wrought ouer with ſilke of two colours from the midle to each end; as for example yellow and white; That part which pointeth to the North let it be wrought ouer with white, and the other with yellow. Then if you hang that in the midle by a fine ſilke thread, and apply it vnto any other *loadſtone*, the South end of the one will readily finde out the North end of the other; and contrariwiſe. In like manner, with this *magneticall* inſtrument you may ſee two pretty concluſions. The one if you touch a knife with the end of a forcible *loadſtone*, whether it be North or South, and hang this wrought one by a ſilke thread in the midle, that

it

it may hang freely, the one end will craue towardes the point of the knife, and the other will not abide it. The other is, if you hang it end-long, with the true North end right ouer the North end of a forcible *loadſtone* or with the South end ouer the South end of the other, you ſhall ſee that it will in no wiſe (being let downe) come vnto the North point of that *loadſtone*, but will (contrary to *philoſophicall* principles that heauie things ſhould tend directly downewards) by the meanes of the ſilke thread, ſwimme or wheele about the end of the *loadſtone* in the aire: yea and lift it ſelfe ſomewhat vpward, rather then perpendicularly light downe vpon it, yea this it will do although you place a plate of ſiluer, lattin, or any ſuch thing, betweene the ſtone and it ſelfe.

The ſecond way.

Thread a common ſowing needle, and touch the point of it with the North end of any *loadſtone*, then offer it vnto that ſtone whoſe points you would find out, holding the needle by the thread about an inch there-from, and in turning the ſtone about, you ſhall preſently ſee the needle point vnto the North end of this ſtone, and flie from the other end, when by your turning it commeth neere. The contrary effect enſueth, if you touch the point of the Needle with the other end of the ſtone, wherein you may behold that ancient conceiued, and of late yeeres maintained errour of the contrarietie of *Magnes* and *Theamedes* to be nothing elſe but a contrarie property of one and the ſelfe ſame *Magnes*.

The

The third way.

Breake off the point of a sowing needle, halfe an inch long or longer (if the stone be good) but not aboue a quarter of an inch, (if it be a base stone) lay it vpon the stone, and moue it to and fro vpon the *Superficies* thereof (being smooth) with the needles point forwards, and as it commeth neere any of the two points of force, it will raise it selfe more and more: but being brought vnto the point it selfe, it will stand there straight vpright; If the stone be ragged this cannot well be practised, otherwise of all other it is the most certaine way. Now whether it be your North or South end the effect will soone declare.

The fourth way.

Hauing an ordinarie Diall with a *magneticall* needle, or a sayling compasse, or any *magneticall* needle standing on a sharpe pinne, hold neere thereunto the stone turning it in your hand, then will the north end of the needle (I meane the end that pointeth to the North) respect the true North point of the stone.

The fift way.

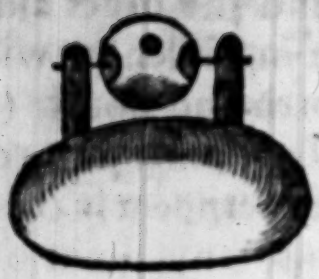
Also if you touch a common sowing needle (the longer the better) and put ti through a little peice of corke, not bigger then may well beare it vp, so that by the meanes thereof, it may swimme in a bason of water, the same if you offer the stone vnto it, will

shew

shew the like effect. And here it is to be remembred, that none other way whatsoeuer will more readily or truely define the *magneticall Meridian*, then this of the needle with corcke in the water. And therefore as it is very requisite for many purposes that euery Traueller either by land or especially by sea should alwaies haue (if he may) an æquinoctiall Diall with him, so would I not wish that any of them should be without some sowing needles touched with a good stone which wil both serue the proper vses of sowing without impairing their touch (for it is open aire and rust that are the greatest enemies thereof) And at any time with a peice of corcke, or a drie sticke in the water will shew the *magneticall meridian*; a matter though meane and triuiall in shew, yet betweene whiles of so great importance that it may serue to saue very many mens liues.

A sixth way.

Also if you prepare a little round *Loadstone* of a quarter of an inch diameter or thereabout (but it must be a very good one) hauing his two poles marked and fitted in such manner that it easily turne about in a little frame according vnto this picture. The like also in his sort will come to passe, if you hang a small declinatorie Needle in a frame in this manner.



Then by mouing it in his frame all ouer the ſtone, the North pole of this will finde the South of the other; And likewiſe will the South, the North of the great one; For it is not in outward ſhew between one *magnet* and another, as it is betweene a *magnet* and a *magneticall* needle, the contrarie ends of the *magnet* will couet in their motion to meete together, but the end of the needle which turneth North, will come vnto the North of the ſtone: For in very truth it is the South point of the needle, euen as the *magnet* it ſelfe being placed in a woodden diſh in water will turne with his North end vnto the South, and with his South end, diſh and all, towards the North, as it is largely declared in the ſecond Chapter of this booke. The like effect will alſo follow if you hang as aforeſaid a ſmall *magnet* in the middle by a ſmall ſilke thread, that it may freely turne without impediment according vnto his owne nature. But this property it will ſhew quicker, or ſlower according vnto the goodneſſe of the ſubſtance, and fitneſſe of the forme. The beſt forme for this purpoſe is the extended ovall, hauing his poles preciſely in his ends. If his poles be ſome pretty diſtance, the one end towards

wards the Eaſt of the ſtone, and the other aſmuch towards the Weſt, this ſtone in his length will not point vnto the *magneticall* North and South (as otherwiſe he would) but vnto ſome other point of the *Horizon*; yea following this experiment in this ſort, you may make him ſtand vnto any point of the Compaſſe: onely you ought to abridge the ſtone in his length that he may come ſomewhat neerer vnto a circuler forme, that ſo his diameter of North and South (being through the *magnetiſme* of the earth, the cauſe of this motion) may be ſo much the longer in compariſon of the Maſſe of the ſtone, and conſequently more effectuall. After the like manner you may ſo touch the wiers of a Compaſſe, that the *Flower de luce* of the flie, ſhall ſtand vnto what point of the *Horizon* you pleaſe, although the Diameter of the wiers doe ſtill remaine fixed vnder the *Flower de luce*, and the South point of the Carde.

Finally to conclude this point with a *magneticall* delight, if you touch two ſowing needles in a contrary ſort, that is, the point of the one northerly and of the other Southerly, and ſet them with their corckes the one at the one ſide of a baſon of water and the other at the other, you ſhall ſee them, as quickned with vitall ſpirit, euen ſo to moue the one end towards the other, at the firſt faire and ſoftly, but when they draw neere they will ruſh together (as it were) with a kinde of violence, the point of the one ſtriking preciſely at the point of the other, you muſt place the needle, whoſe point is touched for the North on the South ſide of of the baſon, and the other on the other ſide: Otherwiſe the heads

and not the points will runne together, a thing farre more worthy of admiration, then all the selfe mooners of any *Dædalus* or *Architas Tarentinus*, and more strange to behold then the connexion of Iron rings combined by vertue *magneticall*, whereat S. *Augustine* so much, and that iustly, did wonder.

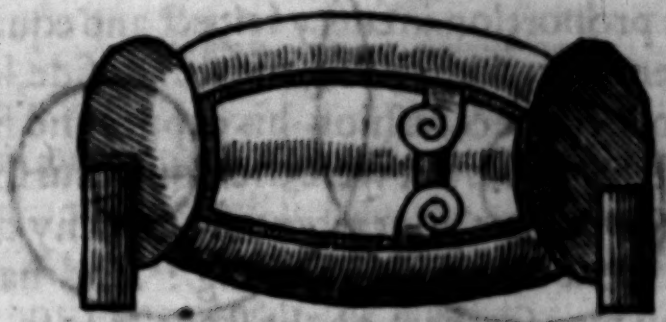
Chap. V.

The manner of capping both with single and double cappes and the nature of them.

THe stone being brought vnto his perfect forme you must haue a mould made of Iron of the very same proportion in euery respect and equall in all his dimensions, then setting the stone aside, let your workeman frame & fashion his cappes and fit them vpon this mould as if it were the stone, thus shall you be sure to preserue your *magnet* from many dangers, very incident vnto rude handling: And having so done you may set them on the stone it selfe, amending any small faults, without endangering the stone, either with bruisings, or knocks; For the thicknesse and largenesse of the cappes, there can bee no generall rule prescribed, but it must be left vnto the triall and ingenious dexterity of the workeman: as also for the handsome fastening either by soadering, or riuetting of them with lattin plates to the Caps to keepe them in their places firme and steddy, according as you see in this picture of a stone, armed with single Cappes.

The

The double Cappes are nothing but two ſquare or round knobs prominent and iſſuing out of the ſingle Cappes (as neere as may be) at right angles with the *Axis* of the ſtone, agreeable to this forme, which was faſhioned by a very skilfull workman



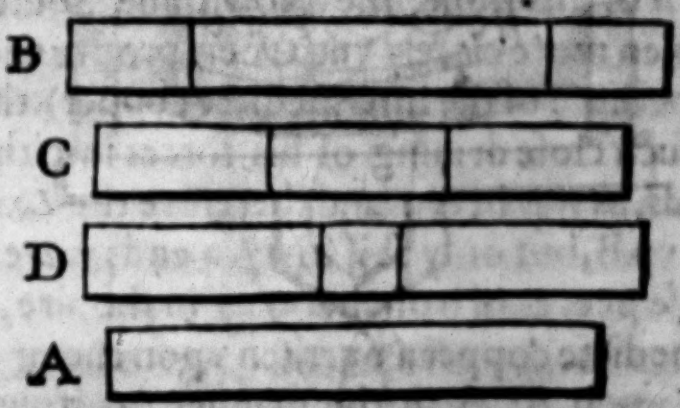
of *Wincheſter*, one that for all manner faſhioning, cutting, ſoadering, peecing, and capping of *Loadſtones*, is the moſt exquiſite that I haue knowne, as Doctor *Gilbert* would alſo confeſſe, who had his beſt faſhioned and capped by him; and ſo ſome Noblemen and diuers Gentlemen, to their great contentment, haue had the like. I finde not as yet any profitable vſe of the double capping, but only for admiration, in taking vp a greater quantitie, more by the one

halfe, then the two ſeuerall ends could doe each by it ſelfe: as if each end will take vp halfe a pound, being capped in this ſort, that each prominent end may lay hold vpon the iron fitted for it in this maner,

it ought to take vp a pound and a halfe and more: The reaſon whereof is this, becauſe the *Magnet*, in touching any one end of a fitting peece of iron or ſteele, doth not onely infuſe the vertue of that end, which toucheth the iron, into that touched end, but alſo the contrary vertue into the other end.

Now therefore in this poſition, both ends of the *Magnet* being applied vnto the two ends of the iron, theſe

theſe two contrary forces ſtriue in this peece of iron, the North to repell the South, and the South the North: ſo that each force is driuen neerer his owne end, and becommeth there ſo much the ſtronger then otherwiſe it would be. For proofe whereof, take a little narrow ſquare peece of iron, of the length of the capped ſtone, and ioyned in the middeſt with Copper after this ſort:



A. is ſuppoſed to be a long ſquare, or a ſquare-like peece of iron, in length fitting the two double caps of a *Loadſtone*.

B. a long ſquare peece, the ends iron, the middle copper. C. hath a leſſe ſpace of copper, and D. leaſt of all.

If you apply the *Loadſtone* vnto A, he will hold A very ſtrongly; but if you put any of the other three peeces vnder A, that it may touch any of them, hee will not by any meanes lift it vp. If you apply the *Loadſtone* vnto B, he will take it vp very weakly, and C ſomewhat more ſtrongly, but D ſtrongeſt of all theſe three, yet not comparable to the ſtrength where-

wherewith hee taketh vp A. Againe, although the *Loadstone* taketh vp B but weakly, yet if you place B vpon A, he will take them both very strongly; yea more, place B vpon C, these two vpon D, all three vpon A, apply the *Loadstone* vnto B, being the vppermost, and he will lift them all vp very easily.

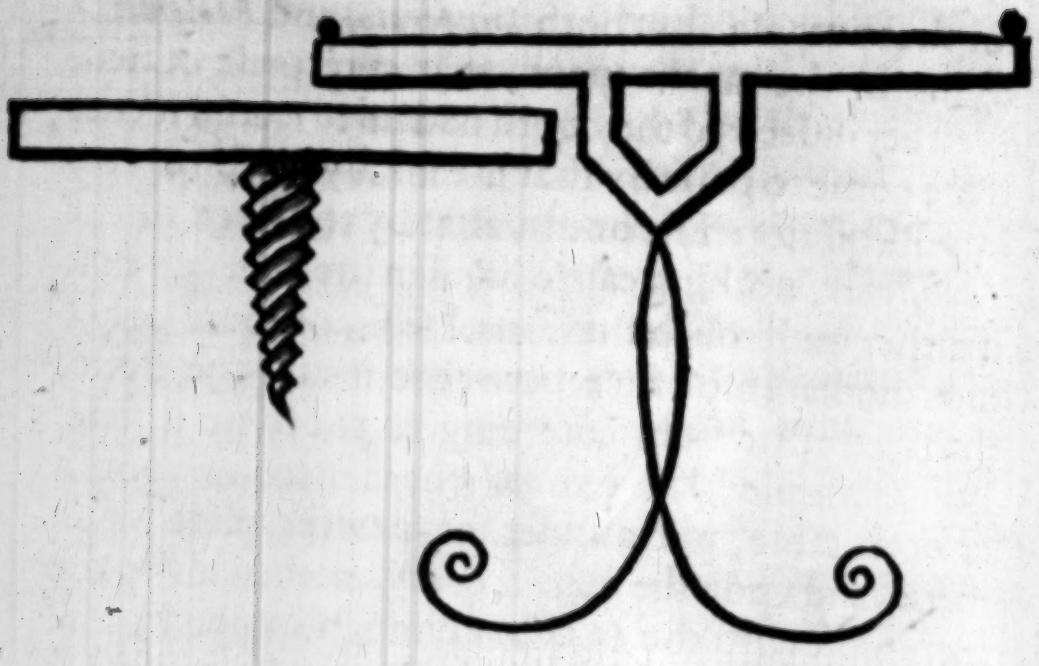
The cause hereof is, when a *Loadstone* with his double cappe is placed vpon A, the force of both ends striuing in that peece of iron paralel-wise vnto the *Axis* of the stone, the North and South forces are driuen more closely vnto their proper ends. But in B, (because of the intermediate copper) there can be no such close driuing of his forces into their proper ends, as was in A: and therefore the *Loadstone* lifteth vp B, but only as if his two ends were two little loose peeces of iron, hanging in the aire, and the intermediate copper a burthen vpon them. But placing B vpon A, A in the manner (as it were) of a bridge, ioyneth the two ends together into their former combats, and the two ends of B, forasmuch as they are but (as it were) two loose peeces of iron hanging in the aire, the two forces of the *Loadstone* North and South, distinctly and seuerally passe thorow them downwards into A, which it could not doe, if it had beene one entire peece of iron: and so all those foure peeces, being placed one vpon another, so that A be vndermost, whether directly or sidewise, the *Loadstone* will easily lift them all vp, and not otherwise.

When a *Loadstone* lifteth vp iron at one end onely, the vertue of the stone is infused into the whole body downward of that iron, if it be not very long.

But

But when by the meanes of the double cappes, both ends doe lift iron ioyntly together, he infuſeth very ſmall force downeward into the body of the iron that it lifteth vp: for the forces of the both ends are ſo ſtriuing in a collaterall line of the iron, paralell vnto the *Axis* of the ſtone, that whereas a good *Magnet* lifting vp at one end, will extend his vertue downewards twelue or fourteene inches, in applying both ends vnto the iron, by the meanes of the double caps, hee will not extend his force downeward the diſtance of one inch, nor with any ſtrength the diſtance of halfe an inch, as in this former example.

If a *Magnet* will lift at one end a pound of iron, faſten you halfe an ounce of iron vnto foure ounces of wood, or any other ſubſtance ſauing iron, and he will neuer take it vp, becauſe his vertue can pierce but onely that halfe ounce, and hath no power to enter into the other ſubſtance; and that ſmall portion of vertue, contained in the halfe ounce, cannot hold vp the other ſtrange ſubſtance. But this very ſame *Magnet*, by the meanes of double caps laying hold of a peece of iron fitted for the purpoſe, and of this faſhion, being but halfe an ounce, may very well and



readily take vp three pounds of any other ſubſtance whatſoeuer that is faſtened vnto it, becauſe that the whole force of the ſtone being imployed in the ſtrife of the contrary ends, in the iron paralell-wiſe, vnto the *Axis* of the ſtone, each end apprehendeth and lifteth vp this peece of iron and a great portion of any other ſubſtance that is faſtened vnto it, and his whole force being imployed herein, all his former vigour, vpward, downeward, or endlong, is as it were fettered and impriſoned, that vntill you looſe him of theſe fetters, hee is not able at either end to take vp one quarter of that which he did before.

Pliny in his naturall hiſtorie writeth, that *Dinocrates* that famous Architect builder of *Alexandria*, at *Ptolemies* commandement began to vault a Temple with *Magnets*, that there might ſeeme to hang in the aire the image of his ſiſter *Arſinoe*, made of iron

for

for that purpoſe: but both *Dinocrates* and *Ptolemie* dying in the meane ſpace, that enterpriſe ceaſed. Neither indeed (if they both had liued) could it euer haue come to paſſe by that means, by reaſon of two impoſſibilities: The one is, that by the force of the *Loadſtones*, nothing can ſo hang in the aire, but that it either muſt touch the ſtone it ſelfe, or ſome other intermediate ſubſtance betweene it and the ſtone, that barreth it from comming to the ſtone it ſelfe. For example, lay two or three needles vpon a ſmooth table, put a ſiluer or pewter plate vpon them, and vpon the plate a *Loadſtone*, then lift vp the plate aloft with the *Loadſtone* lying ſtill vpon it, and you ſhall ſee the needles hanging indeed in the aire endlong, and if you moue the ſtone about the plate, following ſtill vnderneath, but euermore touching the plate, which is the intermediate body, that keepeth them from comming to touch the ſtone, which otherwiſe by their naturall inclination very ſpeedily they would doe. But as for that image of *Arſinoe*; how had it beene poſſible for it to haue touched at once, mediately or immediately, ſo great a number of *Magnets*, whereof the pretended vault muſt needs haue conſiſted? The other is, that ſuch a multitude of *Magnets* would nothing but confound the one the others forces, ſo that one of them alone being ſolitarie and ſeuered from his company, might ſhew more force then al that inſociable ſocietie could doe, each one hindering the efficacie of the other. Much like a teeme of many horſes, where euery one drawing his ſundry way, might ſoone with diſordered ſtretching tire himſelfe and his fellowes, but neuer

moue the loade one iot from the place. Inſomuch as one (and poſſibly the worſt) would doe more good alone, where hee might orderly and freely vſe his owne ſtrength, then hee and all the many of them could doe being ioyned together in vicinitie of bodies, but extremely diſtracted through contrarietie of courſes.

The only way to performe ſuch a matter (if it were worth a doing) would be to prepare one mightie great *Loadſtone* of excellent goodneſſe: which hauing his due proportion, after an extended ouall forme, ſhould be fitted with double cappes, and ſo placed in the roofe of a building, that his *Axis* be paralell to the *Horizon*: in this ſort (out of all doubt) a faire large image might bee held vp very ſtrongly by ſuch a *Magnet*, let the ſtuffe or ſubſtance thereof be whatſoeuer, (howbeit the lighter the better) ſo that there be faſtened vnto the vppermoſt part of the Image a ſmall peece of iron accordingly prepared and placed for the two prominent ends of the double cappes of the ſtone, to lay hold thereon. But enough hereof.

In the capping of *Magnets*, this generall rule is to be obſerued, that they ought to be made of the fineſt and ſofteſt iron, and not of ſteele: the waight alſo, which the *Magnet* taketh vp, ſhould be of the like iron, and not of ſteele, as aforeſaid. For although ſteele retaineth at the leaſt ten times as much vertue as iron, when it is once ſeparated from the ſtone, can doe; yet as long as there is any contiguitie betweene the ſtone and them, hee holdeth iron more ſtrongly then ſteele. Both which differences in either of them

by

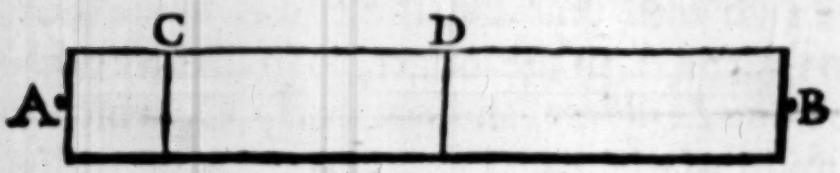
by manifeſt experience are certaine, and ſeeme to proceede of notable faſtneſſe or cloſeneſſe in the ſteele aboue the iron ; by meanes whereof the *magneticall* vertue doth longer and more forcibly continue in that then in this : euen as fire more mightily poſſeſſeth, and for a greater ſpace abideth in ſtone, or any ſuch firme or ſolid matter, then in wood, or ſtraw, or the like thinne and hollow ſubſtances : and therefore thoſe compaſſe-makers, that make the wiers of their flies for ſailing compaſſes of meere iron, ought not by any meanes to be ſuffered : for to gaine two pence in a compaſſe (and ſcarcely that) they intollerably abuſe thoſe that trauell by ſea, to their great danger and miſchiefe.

Chap. VI.

Of cementing and peecing of Loadſtones.

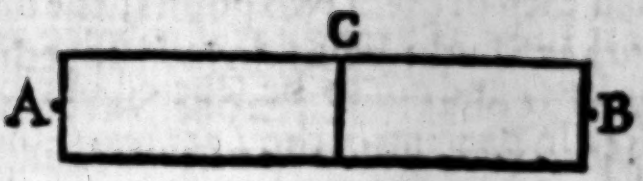
FOr your Simmon, doe thus : Take the fine powder of a *Loadſtone*, halfe ſo much powder of new bricke made very ſmall and ſubtill, one part of *Burgundie* pitch, halfe ſo much Roſſen, a ſmall portion of vnwrought waxe : mingle all theſe together very well vpon a ſoft fire, and make the whole maſſe in little roules. Now when you will cement a ſtone, doe thus : heat the two peeces of the ſtone very hot, and likewiſe the ſimmon, then ſtrake the places that you will ſoder, ouer with the ſimmon very thinly, and ioyne them ſomewhat hard together, letting them ſo ſtand vntill they be cold, and you

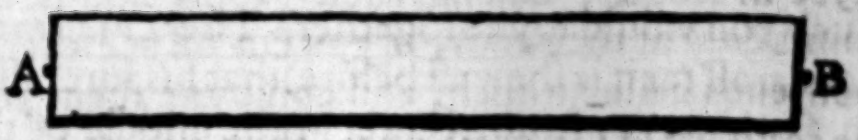
ſhall haue it fully as ſtrong, as if it were an entire ſtone of it ſelfe, and not to be ſeuered but by great heat of fire. In peecing of the *Loadſtones*, there muſt diligent heede be taken to the nature of the *Loadſtone* in generall, and alſo to thoſe particular peeces which you would ioyne together. The *Loadſtone* in generall (as it is ſhewed before) that his force iſſueth (as it were) from a center in the middle of the ſtone, to all the ſuperficies thereof vniuerſally, but moſt ſtrongly vnto the Poles from the middle, one way the ſtone is all of a Northerly nature, and all of it Southerly the other way. For example.



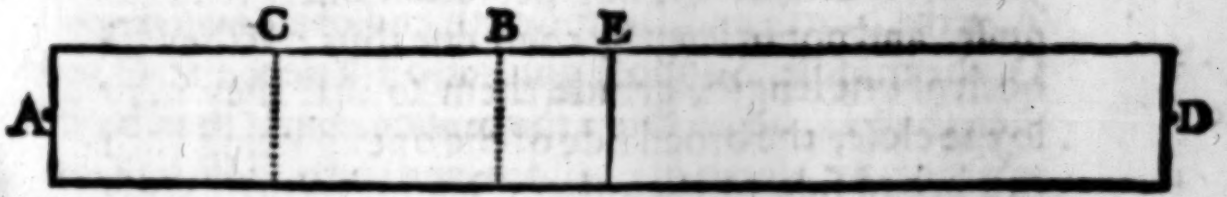
A. is the North end, B. the South end of a *Loadſtone*, D. the middle. Suppoſe you cut off a peece at C, then ſhall D. be no more the middle, but it ſhall be a part of the North of the ſtone, and the middle is remoued neerer B, and the vertue of North and South doth not now diuide it ſelfe at D (as it did before) but D. is now become a part of the North end of the ſtone, which it was not before. In this example following let there

be



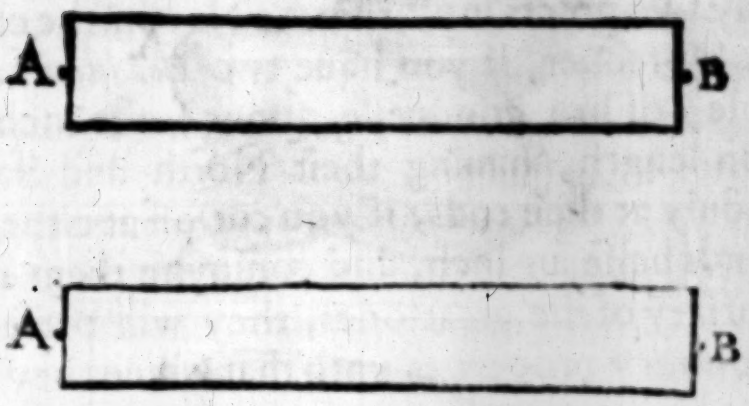


be two *Loadſtones*, the one longer then the other, the North of both noted with A, the South with B, the middle of the ſhorter, where the North and South properties doe part, is C. Suppoſe you will faſten theſe two with ſimmon, the end B. of the ſhorter vnto the end A. of the longer, ſo ſhall theſe two become one *Loadſtone*, and not onely C, which was the middle (where

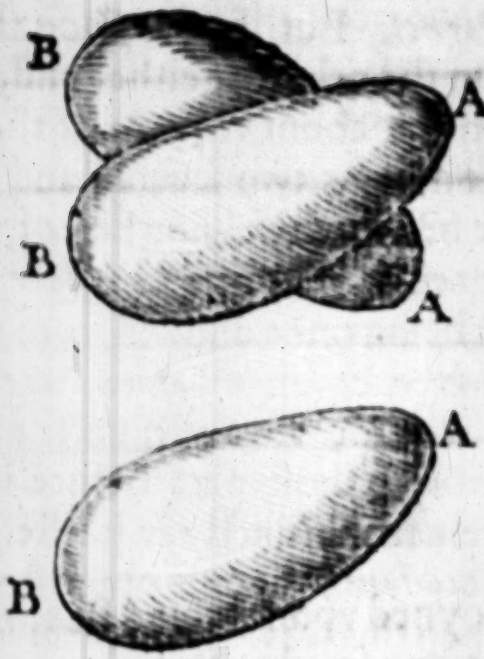


the North and South properties did part) in the little one, is now become a part of the North end in this conioyned *Loadſtone*, but alſo euen B. it ſelfe, which was in the ſhort one the very South Pole, is now in this become part of the North portion, the middle of this (where the North and South properties

ties doe part) being in E, and theſe two *Magnets*, which had each of them two points, the one North and the other South, being ioyned together, haue but only two points in all, the one North, the other South. Moreouer, if you haue two *Loadſtones* (for example) of like goodneſſe, about foure inches a peece in length, hauing their North and South points duly at their ends, if you cut off at either of their ends halfe an inch, and conioyne them with the contrary of the great ones, they will preſently haue contrary properties vnto that which they had before; ſo that a needle touched before that would turne North, being now touched in the ſelfe ſame place will turne South, ſhewing that the vertue of the two ends doth alwayes proceed and extend it ſelfe from the body of the whole *Loadſtone*, and from the whole, ſheweth it ſelfe moſt forcible (as aforeſaid) in the ends; and either of the *Loadſtones* will be in his perfect goodneſſe, as at the firſt. If you thinke good to ſet two *Loadſtones* together in ſuch ſort, that you would haue the augmentation onely in thickneſſe, and not in length, then doe thus: If they be both of one length, grinde them ſo that they may ioyne cloſe, the broad ſide of the one agreeing with the broad ſide of the other, hauing North vpon North, and South vpon South, as in this example.



A. muſt be ioyned vpon A, and B. vpon B : but if you ioyne the two ſo, that A. lighteth vpon B, you marre the new *Magnet*, by confounding his forces. Notwithſtanding if you like to ioyne them in length onely, not in thickneſſe, then indeed muſt you combine B. and A, and not A. and A, nor B. and B, leſt here alſo you incurre the former inconuenience, of confuſion of forces. Take another example : Suppoſe a *Loadſtone* to bee long and ſomewhat round, ſmaller at one end then at the other, the ſmaller end to be North ſigned with A, the other South ſigned with B: let this *Magnet* bee diuided long-wayes into two equall parts, thorow both the Poles, A. and B.



And let one of these halfes be placed vpon a peece of glasse or a smooth Table; certaine it is, that if you do offer to touch A, of this, with A, of the other, this A will turne away from that, which (the stone being entire) it did ioyne with before: Or if you offer B, vnto B, it will doe the like. And no maruaile, for in this case of touching A, with A, or B, with B: what else in effect doe you, but attempt to ioyne the two halfes in length and that at like ends? A thing directly repugnant to the principles of *Magneticall Philosophie*. But let me admonish you, to put the rounder side of the stone downewards, next vnto the glasse, that it may turne the quicker: yet if the stone be excellent it will doe the same also vpon the flat side. Moreouer if you place this two halfes, the one vpon the other precisely as they were at the first, they will agree

agree very well: becauſe they are as one, and the ſelfe-ſame *Magnet*. But if you place them the one ſwaruing from the other, at either end, then will A, of the one, turne about vnto B, of the other; becauſe they are now as two ſeuerall and diuers *Magnets*. For the better conceiuing hereof, you are to remember, that euery part of a *Loadſtone* (be it an half or any other) being once diuided from the whole, is (as Schoole-men call it) *Totum integrale*, a whole *Loadſtone* by it ſelfe, vtterly diuerſe and eſtranged from that whole, whoſe part before it was, and therefore reteineth diſtinctly in it ſelfe, all the properties of a *Loadſtone*, though not ſo ſtrong, as the whole had when this was ioyned therevnto.

In *Loadſtones* there is a part truely ſaid to be diuided from the whole, when the points of that part, or ends, or *Poles* (and ſo, by neceſſary conſequence, the *Axis* and *Æquator*, in which the vniuerſall frame of *Magneticall* power conſiſteth, haue a poſition diuers from the *Poles* or points of the whole. For this cauſe, in the laſt example the one halfe A: B: being ſuppoſed to ſwarue from the other halfe B: A: at either end, muſt needs preſently be diuided from it, and now cannot be *pars integri*, but is of neceſſitie *Totum integrale*, a ſeuerall and abſolute *Magnet* of it ſelfe, and ſo by an eſſentiall property common to all *Magnets*, coueteth with his point A, the contrary B: of that which is vnder it. Wherefore like as exact agreement is betweene two *Mathematicall* figures when being applied together, the extreames of the one, doe preciſely fall vpon the extreames of the other, each vpon his correſpondent extreame, and

is made one therewith: euen ſuch is the perfect compoſition or ſetting together of the parts of a *Magneticall* body, and namely of thoſe two equall parts before exemplified, you muſt ſo ioyne one vpon another, that the two extreames, or ends, be alwaies of the ſame nature Northerly, or Southerly, in both parts: And that by due application of the parts, the two Northerly ends be vnited, and become one, as alſo the two Southerly ends after the ſame manner. But if theſe parts, being of equall length be ioyned longwiſe, the North of the one, vnto the South of the other; thoſe two ends that were (being now no ends but the iuſt middle of one *Magnet*) haue loſt their properties which they had, when they were ends. For thoſe properties, by this vnition, are aboliſhed: but their other ends ſtill reſerue their former and ſtronger vertues of North and South: And ſo, according vnto *Magneticall* nature, one *Magnet* ſhall haue but two *Poles*, the one North, the other South. Againe, if you will peece two *Loadſtones* together in thicknes, the one of thē being longer, than the other; then you muſt either cut the longer, that it may be fit in length, vnto the ſhorter; or elſe peece the ſhorter in ſuch ſort as is afore deſcribed that he be equall in length to the longer, & what ſoeuer diſorderly parts perhaps ſhall bee in any of them, they may, euen after they are cemented, very well be ground away. Alſo if there bee holes or dents, with little peeces of *Loadſtones* cemented (their points being obſerued) they may be filled vp, without any manner of dammage or deformitie, no more than there had not been any ſuch at all. And

after

after this method you may (with labour and industry) of many *Magnets*, make one as huge, and of what forme you please. And although the *Magnets* of this body, magnetically compact (as I haue here shewed) were neuer so many in number, yet the whole will haue but two principall points, the one North, the other South, euen as if it were one naturall *Loadstone*: and all of them will contribute their forces, vnto those two points; So that if there were twenty of them, being after this order cemented together into one body, the whole would haue but two points, but if you will place them in a vault, according to a *Masons* trade they will haue 40 points, twenty North, and as many South, and will worke the like effect in drawing yron, as (to vse the former grosse similitude) if a teeme of horses were set in their traces contrary the one to the other, the one to pull one way, the other another. As for the Turkes *Mahomet*, hanging in the ayer with his yron chest it is a most grosse vntruth, and vtterly impossible is it for any thing so to hange in the ayer by any *Magneticall* power, but that either it must touch the stone it selfe, or else some intermediate body, that hindreth it from comming to the stone (like as before I haue shewed) or else some stay below to keepe it from ascending, as some small wier that may scantly bee seene or perceiued.

Chap. VII.

Of the variation of the Magneticall Needle with the Appurtenances thereunto belonging.

THE variation of the Magneticall Needle, being aptly fitted and placed vpon his pinne, is nothing elſe, but the ſwaruing of the pointing thereof in the *Horizon*, from the meridian line there, the portion of the *Horizon* intercepted betweene the true Meridian line and this pointing, ſheweth of what quantitie the variation is, and giueth it his name, to wit, which way it lyeth, either Eaſterly, or Weſterly, and it is obſerued by either end of the needle as you pleaſe.

In times paſt men obſerued onely by the North end of the needle, becauſe they vnderſtood not that the *Loadſtone* hath a South vertue, as well as a North; And therefore did touch their needles and wyars of their compaſſes alwaies for the North onely, leauing thoſe ends of the wyars bare, that they might be refreſhed with a new touch at any time afterwards: but the other ends they couered, not knowing that they were alſo apt to receiue as forcible a vertue from the *Loadſtone* for the South, as the other for the North. For the right vnderſtanding of the variation, with his neceſſary dependants, wee muſt vſe the meanes of two circles: The one of them I will call the *Magneticall Almicanter*; The other is already knowne by the name of the *Magneticall Meridian*.

This *Magneticall Almicanter* is a circle paralell vnto the

the *Horizon*, whose center is the verticall point, and is described by the distance betweene the verticall point, and the neerer *Pole* of the earth. The true *Magneticall Pole* is the *pole* of the earth; The *magneticall* respectiue Pole, or (which is all one) the Pole of the *Magneticall Meridian*, is a point in the *Magneticall almicanter*, distant Easterly or Westerly from the true pole as many degrees in that *almicanter*, as the variation of that place containeth in the *Horizon*, but alwaies it is in the contrary part of the true *Meridian*, that is, if the variation of the South point of the neede bee Easterly the respectiue pole is Westerly: but if you obserue with the North end of the needle, the respectiue pole and the variation are both one way in all our Northerne Climates. If the variation of the South point of the needle bee Westerly, then is the respectiue pole so many degrees in the said *almicanter* Easterly, and therefore alwaies of the same height with the true pole aboue the *Horizon*. For since all great Circles of the globe doe necessarily cut one another in two points into two equall parts: these two therefore must needes doe euen so in the *Zenith* and *Nadir*, by their very definitions; So that these two points (the *Zenith* and *Nadir*) are alwaies alike common vnto them both, aswell vnto the true, as vnto the *Magneticall Meridian*.

Where-hence it followeth necessarily, that alwaies the one halfe of the *magneticall meridian* is on the East-side, and the other on the West side of the true *meridian*, the common *Zenith* and *Nadir* euermore keeping their equall distances from the Poles of:

of the one of them, as they doe from the other. For example: Suppose the common *Zenith* to be in the *Æquator*, you sayling East or West, as long as there is no variation, there is no *magneticall meridian*, there are no *magneticall Poles*, but those of the world. But as soone as, sayling still vnder the line you doe finde a variation it is the *magneticall meridian*, that by his swaruing from the true *meridian* of the world in the *Horizon* sheweth the quantity of the variation, and giueth it also the denomination of Easterly or Westerly, and his *axis* is the line of variation. But supposing the common *Zenith*, to be in any paralel, betweene the *Æquator* and the *Pole*, then is it not the *axis*, but some other *Diameter* of the *magneticall meridian*, which sheweth the variation in the *Horizon*; And the *magneticall meridian* euermore cutteth iust so many degrees of the *magneticall almicanter* on the one side of the true *meridian*, as the same *Magneticall Pole* is distant in the same *almicanter*, on the other side of the true *Meridian* from the *Pole* of the World. And this is to be vnderstood in correspondent manner, as well of the South *Hemisphere*, as of the North.

The respective *Magneticall meridian* (where any variation is) is a circle that passeth by the verticall point and the Nadir, and both the respective *Poles*, crossing the *Horizon* at right angles in the points of variation, of which circle the line of variation is a *Diameter*, but where there is no variation the true and *Magneticall meridian* are both one & the selfe same, and so in like manner are their *Diameters*. Those circles and poles are tearmed respective because that in euery

euery place where any variation is, the *Magneticall* needle doth respect them, as well in the property of direction, as in that of declination, or inclination. For thus also very well it may bee tearmed. By the property of direction, I doe meane, with Doctour *Gilbert*, the *Horizontall* motion of the *Magneticall* needle: By the declination, or inclination, I meane the descending, and (as it were) the sinking motion of the neede vnder the *Horizon*, in his proper *Azimath*, or *Magneticall meridian*; But if there be no variation, the needle alwaies pointeth vnto the true *Meridian* of the earth, and towards the Poles therof, in both those properties. The true Poles of the earth (which are those two points equally distant from each part of the *Aequinoctiall* of the earth are alwaies the selfe same. The respective *Poles* alter with euery *Horizon*, where there is any variation, but neuer out of the aforenamed *almicanter* of that place. The causes of the differences of the respective *Poles* and *Meridians* from the true *Poles* and *meridians*, and so of all variations, are onely two; The chiefe and most generall is the vastenesse of the Ocean sea, by moistnesse whereof the *Magneticall* collaterall force of so much earth as it couereth, is much hindered and dulled. And by that meanes the next great Continent hath more power ouer the correspondent end of the *Magneticall* needle, then otherwise it could haue if all were alike one entire Continent: and therefore causeth the directiue property of the needle somewhat to swarue towards that way, which is that, which we call variation; but yet the vastenesse of the Ocean doth not hinder the decli-

nation of the *Magneticall* needle; Because his hangings consisteth but in length and breadth, and not in depth. For although in comparison of a pond or riuer, the sea is said to be of a wonderfull depth, yet if this depth be compared with a *Semidiameter* of the earth, it beareth a very exceeding small proportion, nothing at all to hinder the mightie *magneticall* declinatory force of the whole earth; For the greatest depth that euer any man of skill esteemed it at, was not aboue two English mile, at the vttermost, when as daily experience maketh it manifest, that a great Continent wil shew his *Magnetticall* collaterall force, by causing a variation, aboue two hundred miles of from the place, and therefore Doctor *Gilberts* feare in that point I take to be needlesse, supposing a variation of declination. The second cause of variation, is any great mountainous region not farre of, when a man is in some great *Latitude* towards either of the *Poles*: if that mountainous region lie Easterly or Westerly from you, it will cause the needle somewhat to swarue that way. But variations of this sort are of small continuance, and in sayling subiect vnto sudaine alterations, yea many times quite contrary from Westerly to Easterly & afterwards backe againe within short space: as our first famous Pilote *Steuen Burrough* found by his experience in the discouery of the *Scythian* sea-coast between the north Cape of *Finmarke* and *Vaygates*. The reason whereof ought heedfully to be regarded which is that the *Magneticall force* of the whole earth, doth (as in all *Magnets*) shew it selfe most strongely in the two *Poles* thereof, and in those places which are neere vn-

to

to them: but alwayes it must be remembred, that all the force they haue doth issue out of the whole terrestriall body, as it doth likewise in all *Magnets* out of the body of the *Magnet*: and therefore in any part of the superficies of the whole terrestriall body, it is impossible that any variation be aboue 90. degrees, because the vertue of the whole can neuer bee ouerswaied by the imperfection of a part, and especially of so small a part as any one portion of the Ocean is in his very superficies, in respect of the body of the whole earth: yea I am thorowly perswaded, that there neuer was nor euer will bee any variation, by any good obseruation found for to bee so much as ninety; neither any shew of so great variation any where, except it bee very neere vnto either of the Poles, where there is small credit to be giuen to the obseruing of any variation: for the variation being (as aforesaid) the difference of the pointing of the *magneticall Needle* in the Horizon from the true Meridian, forasmuch as in places neere the Pole, there is no manner of certaintie of either of these, it is not possible to finde the variation, if there be any. The reason whereof is this, no man may trauell those Seas, but whiles the Sunne abideth on that side of the Æquator, whereby they haue continuall day, and by that meanes are secluded from any helpe of the starres, neither if they might bee seene, would they bring any great helpe. For the difference of heighth in many houres is so small, that by a very large instrument a diligent obseruer with great paines will hardly finde the Meridian Line, all the Meridians themselues comming

so neere one to another, and meeting in the Pole, and their Horizon being in a manner paralell vnto the Æquinoctiall. And as for the horizontall *magneticall Needles*, to shew their pointing in the Horizon as they were wont to doe, they comming into this climate may say, *Fuimus Troes*. Their direction is as it were giddy and vncertaine, and when their center commeth vnto the Pole it selfe, it is quite vanished away; for from thence all the points of the Horizon are onely South, if it be at the North Pole, and North from the South Pole, and therefore in that place the instrument of declination is farre more sure then the Horizontall Compasse. And as in the Poles themselues there is no direction at all, so of necessitie neere vnto them it must bee a very confused direction. Those two places, that are called the Poles, haue no strength of themselues (as aforesaid) but as it is contributed vnto them of the whole. As in a *Magnet*, if you breake off a peece of the contrary end, the end that is left will bee according vnto that proportion diminished in his strength, and the polar peece, that was broken off (be it neuer so little) will haue two poles as well as the great: so that the two parts will haue foure Poles, two of them North, and two South. Put this little peece that was broken off, in his place againe, and then each peece will lose one of his Poles in the same very instant, and the whole will haue but two Poles, the one North, the other South, as at the first. Againe, if you cut off a peece of one side of a *Loadstone*, that is brought into a round or an ovall forme, hauing his Poles marked in their due places

at

at each end, presently both ends will be abridged of part of the force they had, and the Poles themselues will be remoued vnto the other side, from the places that were marked, and those markes will stand but for idle ciphers in comparison of that they were before. Againe, take a *Magnet* of a round or an extended ouall forme, (I doe still exemplifie in these, because they are of all others, as I haue often admonished, for all *magneticall* proofes the most excellent formes) and set markes on the two Poles, take a fine needle, or any straight small wier, and set it on the æquinoctiall, (I meane thereby the middle betweene the two ends of the stone) then will it point directly towards each Pole, if the stone bee sound without any flawes, or any other grosse substance (as may bee) intermingled with it: and if you thrust this needle towards either end, according vnto his owne direction he will trace you a circle right ouer both of these marked Poles, which is the true Meridian of the stone. But if this stone hath in either of the sides any imperfection, when the needle commeth vnto the edge or brinke thereof, it will swarue somewhat towards the sounder side, and will point to neither of the true Poles. And if a circle bee drawne according to his pointing, as hee standeth still in that place, this shall be a respectiue Meridian of that stone, proper vnto that place: and the Poles. therespectiue Poles, differing from the true Meridian of the stone and his Poles. Now if you thrust the needle further towards the end, vpon the brinke of this imperfection, it will not point (as before) but either further off, or neerer towards the true Poles,

and will giue his direction for a new respective Meridian; and new respective Poles, And in such manner infinitely, if you place the needle in the middle of this imperfection, equally distant from the sound parts, then will it indeede poynt towards the true Poles of the stone, And the Consequence heereof is the maine reason, that towards the midst of the Ocean; and likewise of any great continent there is no variation. Thus may you especially, in a round *Loadstone* (as in a liuely example) see the true causes of all the variations that are in the whole world, reckoning as much space as the Ocean couereth, to bee some imperfection in the body of the whole, in respect of the Horizontall motion of the Compasse. For the euidence of the truth heereof, let a man examine generally the variations of our most expert Nauigators (Although by reason of their diuersities of the sets of their Compasses, and vnfitnesse and vnapt handling of their instruments, they very seldome times agree among themselues) obserued in the Atlanticke Ocean, from the Æquator vnto the parts of *Norway*, all along the East coast from the Meridian of the Azores: And in like manner from the Æquator to the parts of New found land and vpwards, all along the Westerne Coast from the Azores, as farre North, as heereunto hath beene discouered, and he shall finde the ordinary practise to testifie the truth heereof, as also after the same sort from the Æquator Southward vnto the straights of *Magellan*, and all along the backeside of *America* in the South Sea: and on the East Coast vnto the Cape of *Bona sperança*, and he shall perceiue the like agreement: But in

sailing

sailing from the Cape of *Bona sperança*, farther Eastward, that sometime they doe finde it otherwise, the cause is the different manner of the scituation of the South, as yet vndiscouered Continent. And wheras in the middest of the Atlanticke Ocean, about 30. leagues Westwards from the *Azores*, they find no variation at all, no maruell thereof: For it is about the middle distance betweene the two great Continents of *America* and ours.

Wherefore the round *Loadstone* is significantly termed by *Doct. Gilbert Terrella*, that is, a little, or rather a very little Earth: For it representeth in an exceeding small modell (as it were) the admirable properties magneticall of the huge Globe of the earth. Heerein also wee may beholde the reason why, the magneticall needle varieth least in the Æquinoctiall, and most towards the Pole, and in the Poles themselues giueth no direction at all: For proose heereof, take a needle and place it vpon the Æquinoctial of the stone, there you shal see him stand equally ballanced and very strongly, so that if you turne him from his direction, as soon as you let him goe, hee will presently turne vnto it againe. The reason is, because each Pole doth equally strengthen his correspondent end of the needle. Moone this needle toward either of the Poles, then doth the neerer Pole strengthen his end of the needle; but the farther (because of the distance) cannot doe the like vnto his, but very weakly, and this needle will not stand any more equally ballanced (as it did in the Æquinoctiall) but that end next the Pole will couch downe, and the other will rise vp. For on the North

side

side of the Æquator, the true South end is predominant, and on the other the North end hath the mastery. And that this is also in the earth it selfe, all our late Trauellers confirme vnto vs by their daily experience, and all the very Artizans and needle-diall-makers in the world must needes be daily witnesses of it. As for example: Let any workman in our Climate make a needle for a diall, when he hath fitted it and placed it on the pinne, that it may stand thereon equally ballanced and paralell to the *Horizon* touch it with the Magnet, then presently that which pointeth towards the North will hang downe (yea, although you touch onely with the South end) and will not stand, as before the touch equally ballanced and paralell to the *Horizon*: except you cut or file somewhat from that end, that hangeth downe; or else adde a peece of waxe or some other thing vnto the other end of the needle to counterpoise it, and make it stand equidistant as it did at the first setting on: and this is a thing very certaine, that this Northerly descent of the needle, will be more or lesse in all places of Northerly Latitude: In the greater Latitude the more, and in the lesser Latitude the lesse. But if any traueller carry this needle beyond the Æquator in the like Latitude Southerly, that end which tendeth downewards in the Northerly, will rise vp in the Southerly, and the other sincke downe, euen as much: and the neerer you trauaile towards either Pole, the more, that end which pointeth towards the Pole, will tend downewards: This is most certaine in euery Diall-needle: but a great deale more apparant it is in a long one,

then

then it is in a ſhort one. Wee cannot find that the property of direction by the Magnetical needle hath beene vulgarly practized (for ſailing) much aboue 200. yeeres. And as for the property of declination vnder the Horizon, thereby to ſhew the Latitude by the Inſtrument thereunto belonging, it is as yet a very new-come gueſt into the world, borne and bred with vs in England, and (except it bee in exceeding few mens hands) not yet in vſe, much leſſe come vnto his perfection. But this it not to be maruelled at: becauſe it is ſcantly ſixteene yeeres olde; neither is it to bee wondred if any Criticall fellowes doe contemne and deride it. Foraſmuch as either their want of knowledge, or of patience, will not giue them leaue truely to conſider of it. But what Nauigator, or rather Nugator ſoeuer contemneth it, ſhall bee ſure to repent it if euer hee come to his right wits to conſider what it is that he hath contemned. And although the needles for direction and declination doe differ much in their ſhapes, each from other; yet the properties are both one and the ſelfe ſame. For the needles for direction doe decline (as aforeſayd) as farre as the vnfitneſſe of their forme and placing will permit them: and the declining needle will not worke, but onely in his Magneticall Meridian, which himſelfe will finde out, if you turne the Inſtrument about, vntill the needle ſhew his leaſt declination vnder the Horizon, and there doe play vp and downe, & ſtop in the end in the ſame place again. But if you would haue a needle fitted to ſhew both properties, doe thus, cauſe a needle to bee made about ſixe inches long, euen and ſmooth, ſauing that

he must be a little bigger in the middle, then insteed of an *Axis* (which declinatory needles haue) let him haue a small hole drilled precisely in the middest, and this hole being very small, let it bee somewhat wider outwards on each side then in the middest, (which our workmen call *sinckboared*) where it must bee left very sharpe, euen almost as the edge of a knife: put through this hole a small verginall lattine wiar, and fit the needle so that it hang precisely euen vpon this wiar, insteed of an Axletree: then touch him with the Loadstone, and you shall presently see the end that should point towards the North, decline or bend downe to his due place of declination, if he be placed in the Magneticall Meridian; set a little peece of waxe or any other thing vpon the contrary part for a counterpoyse that the needle may stand paralell with the Horizon, then if it stand at right angles with that verginall wiar, it is certainly in the Magneticall Meridian: otherwise it will neuer stand at right angles, but will make his sharper angle alwayes towards the Magneticall Meridian. So that hanging in this counterpoise if you turne about the wiar vntill the needle doe make right Angles with it, then doth the needle by his directiue vertue poynt vnto the *Magneticall Meridian* line. Take off the counterpoise, then it sheweth the declination for that place, and by consequent the Latitude, if you in that manner place him in the Instrument of declination; so that one and the selfe same needle in the same place onely, by taking off, and putting on a little peece of wax, sheweth plainely both those properties of directions and declinations, as in like manner

ner euery inclinatory needle will doe, if the poynts of his Axis be sharpe, and held in his boxe paralell vnto the Horizon, he will shew both those properties of direction and declination: A fine peece of corcke or leather, or any tough substance may serue this needle for a counterpoyse in all Latitudes by thrusting it towards the center in lesse Latitudes, and towards the end in the greater, and I thinke it not impossible, but that a skilfull Geometrician may so graduate the one halfe of such a needle, that it alone with his counterpoyse, may bee a meanes to giue a probable coniecture for the Latitude of any place whatsoeuer.

Chap. VIII.

A discouery of errours committed in making and touching Magneticall Needles and Wyars of sayling Compasses, with an aduise for the true and right making and touching of them.

First the wyars that are commonly made both with vs, and in forraine countries, are of so base and drossie iron, not apt nor sufficient to receiue the tenth part of the vertue that fine steele wyar could doe.

Secondly, the ends of the wiars bee for the most part not filed smooth nor fitted euen together vpon the *Axis* of the flie; By meanes whereof the touch of the stone is more dully receiued, and the standing

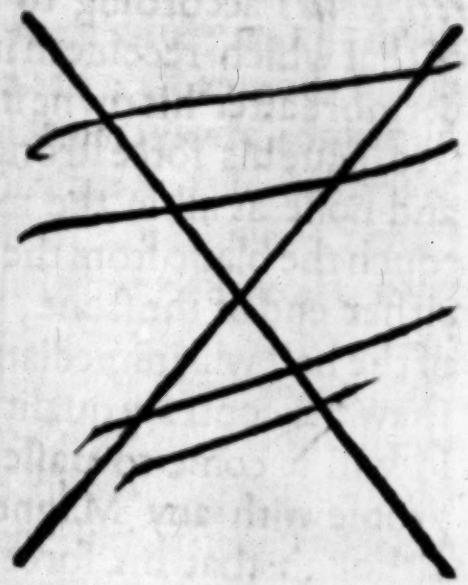
of the flie, the more vncertain, the magneticall force not being in the true axis thereof.

Thirdly, their manner of touching the wiars is altogether pittifull and ridiculous. For with a Magnet hauing a point (for ſeldome times they haue a ſtone ſo well faſhioned, that both poynts are eminent) that toucheth to the North (And ſuch an one, though hee bee but weake is preferred among them before another, thogh much ſtronger that toucheth to the South) they rub to and fro thoſe ends of the wiars, which they would haue ſtand Northerly. Wherein what doe they elſe, but play (as it were) faſt and looſe, not conſidering (as the truth is indeed) that euery touch from the ends of the wairs towards the Center of the flie with-draweth backe-again that force, which the contrary touch did giue them, and therefore ſeldome giue they aboue one quarter of that ſtrength, and ſomtimes not ſo much, which otherwiſe with the very ſame ſtone they might doe, if they ordered all things as they ſhould: yea, I am infallibly aſſured (for I haue had certaine experience of it) that with the ſelfe ſame ſtone, you may giue fully as much, and rather more force, touching in ſuch ſort, as immediately ſhall bee declared on the vpper face of the flie: ouer againſt the wiars (the card being betweene) then they doe by touching the very end of the wiars themſelues after their wonted fathion: whenſoeuer therefore a needle is to be touched, beſides the goodneſſe and quantity, you muſt haue a regard to the forme of your ſtone, namely, whether it hath both the North and South points eminent and ſo cible, or onely the one. For if it hath

both

both, beginne your touching neere vnto the middle preſſing the true North point, before ſpecified of the ſtone all along from thence, vnto the North pointing end of the needle; iterating thoſe touches foure or fiue times, alwayes making ſome ſtay with the ſtone at the end of the needle. The like alſo muſt you doe from the middle with the other end of the ſtone vnto the other end of the needle. But if the ſtone haue but one forcible point, then if it bee the true North, begin your touching at the South pointing end of the needle, preſſing it all along to the North, end, itterating this foure or fiue trmes, and then once or twiſe onely from the middle vnto that end, If the ſtone hath but the South point, touch the needle accordingly from the other end; For euen as the vertue of the ſtone it ſelfe is a *Semidiameter* (hauing his beginnning (as before is mentioned) in the center of the ſtone, euen ſo the force which he imparteth vnto the needle, is in the nature of a *Semidiameter* from the middle of the needle. Inſomuch that a needle being touched from the middle, but to one end with the North of a ſtone, it doth not onely cauſe that end to turne North, but it tranſmitteth alſo a contrary force from the middle into the other end of the needle, ſo that the ſtone be good, and the needle but of a reaſonable conuenient ſize, as you may euidently trie in euery knife of ordinary goodneſſe and length. But a plate of ſteele made at both ends alike, according vnto the forme heere aboue deſcribed, is much better to ſhew this effect. For when the blade of a knife is of fine mettall, the haft being of courſe iron, and alſo of a diuers forme and temper, it is not any

way capable of the like force as the blade is, which is the reaſon that if you touch the blade of an iron-hafted knife from the haft vnto the poynt with a Magnet, it will at the poynt take vp his competent waight, touch it backe againe vnto the vttermoſt end of the haft it wil take vp little or nothing: Try the like with ſuch a plate or ſteele, and you ſhall finde it take vp fully as much at the one end as it did at the other: but if you will bring his touch vnto the middle, it will take vp little or nothing at any end, and nothing at all in the middle it ſelfe:



The

The reason heereof is this, the Magnet giueth his force (*Secundum mensuram recipientis*) according to the capacity of that which receiueth it, and that euermore after his owne nature, which is to haue his force strong in his ends, and none at all in the middle, if you touch the blade from the middle, with either end of the stone, the other end of the haft will immediate receiue and shew the contrary quality: euen so also will it come to passe, if you make proofe with any Magneticall needle, although that his force will bee faint and weake in comparison of the other. And in your touching you must obserue, that in pressing with the stone from the middle of the needle vnto the end, as you bring your hand backward to iterate the touch, you must lift your hand somewhat high, and not bring it backeward, close to the needle. For that would diminish the strength of the touch. But if that end of the needle be also touched with the other end of the stone, in manner as aboue I haue rehearsed, then shall hee at each end be a great deale the more strong, and the contrary fainter forces shall recoile and settle in the middle of the needle, where they can nothing at all disturbe the motion thereof.

CHAP.

Chap. IX.

Of the touching with a Laadstone capped and without the cappe.

BY capping, is meant the placing of two peeces of iron handsomely fitted and fastened vpon the two points of the stone, for iron for this purpose is better then steele. And likewise concerning the the waight that is to bee lifted vp, it is better to bee made of soft iron then of steele, and the stone will lift more therof, as long as there is contiguity: but if if the iron and steele be separated from the contiguity of the stone, the steele will alwayes carry at the least tenne times more vertue then the iron, as is before mentioned. Now whether it were best to touch the wiers with a Magnet being thus capped, or with the bare stone it selfe, some there be that make a question. I haue beene tolde by one of great skill and practise, that he found by experience, the Compasse touched with a capped stone, not to receiue his force so well, as the other, and the party comming vnto me, when he was to vndertake a long voyage, to haue his compasse touched, requested mee in any wise to doe it with the bare stone: But yet I thinke it were good, that this bee confirmed by more then one mans experience, before it be beleeued, because by some error he might possibly mistake the matter. Sure I am that the capped stone giueth somewhat more vertue in his touch, and by all experience that I haue made, I finde it to continue as firmely and as long.

long. Howbeit I referre mee heerein to the triall of others also. A man may therefore touch the wiars first with the bare stone, & then with the same being capped, or contrariwise to bee surer of the greater force, and yet if any shall imagine the difference of the strength of the touch, to be according to the taking vp of iron with the cap or without it, he is very greatly deceiued. For I haue often tried them both, but neuer could see the touching strength in the needle to be increased halfe a quarter more with the cap then without it; whereas I haue alwayes (especially if the stone were very good) found that the stone wil lift at the least ten times as much iron: yea, a great deale more, (and sometimes twenty times) with the cap (if it be artificially fitted) then he is able to doe without it.

Some, who would seeme to be of great skill, haue imagined, that the best way to adde strength to a needle, is with a hammer to giue some forcible strokes to one point of the stone, thereby causing litragges (as it were) or beard, to hang downe from it, & that the needle in his touching, taking some part of that with him, should haue the stronger touch. But they that so suppose deceiue themselues therin: for that beard is nothing else, but the fine dust of the stone, hanging together by vertue thereof: which being separated from the stone (although it were a right good one) is not able any whit at all to turne a needle of it selfe. The triall is soone made by this meanes, let them take of that beard from the stone with a sticke, and lay it vpon the end of a needle not touched, and they shall finde in it no force at all, nay

it is a hurt vnto the needle. For it giueth a ſuperfluous burthen for a ſmall time, and cannot but incumber his action, by reaſon that euery one of thoſe little parcels of duſt (though beaten out at one end) hath alſo for his ſmall quantity both a *North* and *South* vertue. And therefore marreth as much as it maketh at either end of the needle. The proofe heereof is manifeſt, if you put off that duſt or beard vpon a paper, and hold a Magnet therunder, for as you turne towards the paper the North or South of the ſtone, ſo will euery one of thoſe particles in like ſort turne it ſelfe, ſhewing thereby a double nature.

Chap. X.

Of the faſhioning of the compaſſe needle.

THe Compaſſe needle, being the moſt admirable and vſefull inſtrument of the whole world, is both amongſt ours and other nations for the moſt part, ſo bungerly and abſurdly contriued, as nothing more. And therefore entreating now of the nature and vſe of the Magnet. I haue thought good, alſo, to employ my beſt endeauour, to aduance this noble inſtrument towards his higheſt perfection, being the principall thing, by which the worthy effect of the Magnet, is made moſt profitable vnto mankinde. Heerein fiue things are to be conſidered, the ſubſtance that it is made of, the forme, the waight, the capitell, and the pin it ſtandeth vpon: The ſubſtance

in

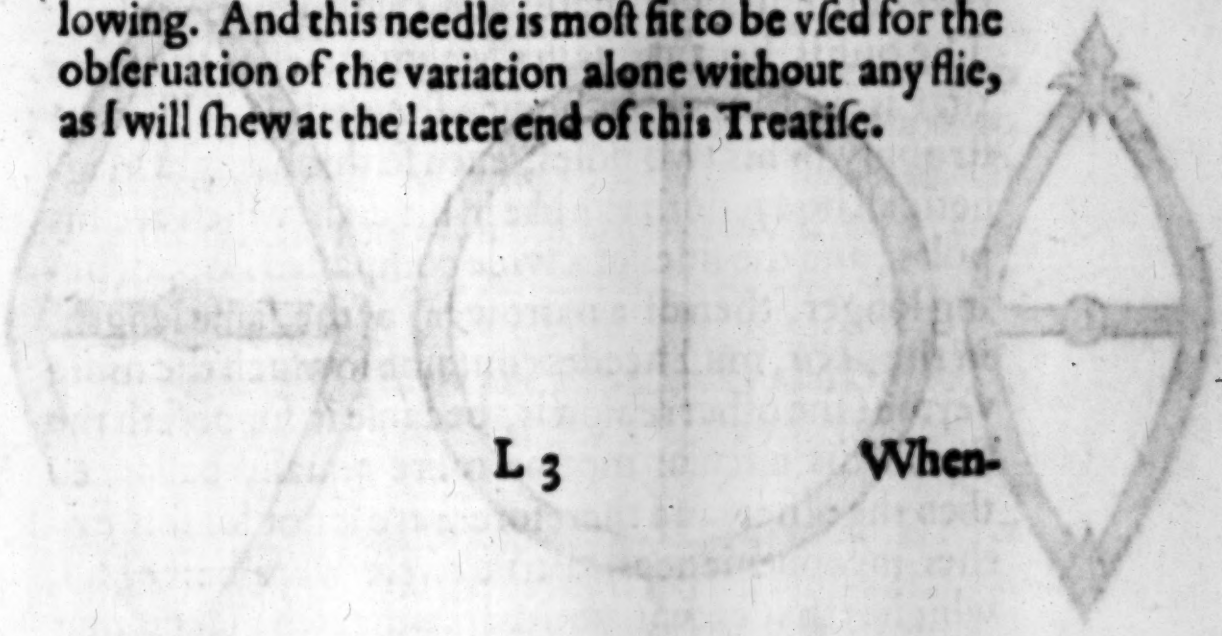
in any wiſe ought ro bee pure ſteele, and not iron. For moſt aſſuredly ſteele will take at the leaſt tenne times more vertue then iron can doe, but eſpecially if it hath his right temper. And that is this: Heat it in the fire vntill it be paſt red hot, that it be whitiſh hot and qnench it in cold water ſuddenly: So is it brickle in a manner as glaſſe it ſelfe, and is at that time incapable of the vertue of the *Loadſtone*. Then muſt you, laying it vpon a plaine table, warily rubbe with fine ſand all the blacke cullour from it, if before you put it into the fire, you annoynt it with ſoape, it will ſcale white of it ſelfe, then heat a barre of iron well neere red hot, and holding one end of the needle with a ſmall paire of tongs, lay the other end vpon the hot barre, and preſently you ſhall ſee that end turne from white to a yellowiſh, and after to a blewiſh cullour, then take that end with your tongs, and doe the like vnto the other, thruſting it forward vpon the barre vntill the cullour of the whole needle become blewiſh: then throw it on a table, and let coole of it ſelfe: and ſo is he of the excellenteſt temper, and moſt capable to receiue the greateſt power from the Magnet. If this ſeeme too curious eſpecially for ſome faſhions of needles, then vſe but the hammer hardening (as workmen call it) which is well neere as good. As concerning the forme, diuers men are of diuers mindes, ſome vſe a kind of ſquare one, others a loop (I meane an extended ouall forme) and this is moſt common. But now a dayes, a narrow ſtraight plate (being ſomewhat broader in the middle) is in great requeſt: Of theſe three I holde the loope or ouall forme (if it bee well made) to bee the beſt, which is,

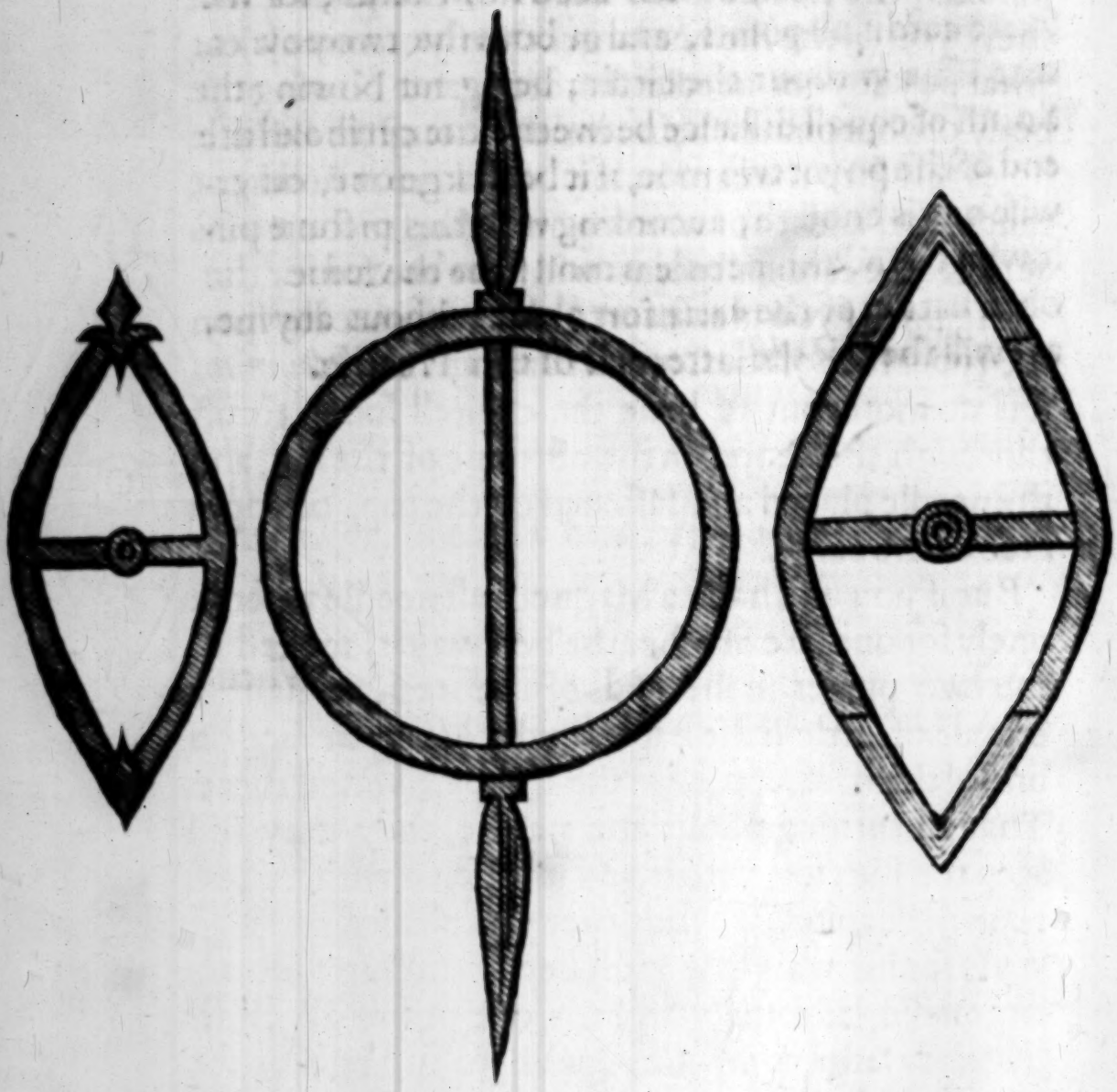
that if it be of ſteele, his ends be welded together, hauing a lattin narrow plate, iſſuing from the capitell vnto the middle of the two ſides of the Loope, and there riuetted, and riuetting, if it bee handſomely ſhouldered in by the workman, is better then ſoadering: becauſe, hauing fitted the lattin plate bearing the capitell vnto the Loope, you may firſt put your Loope into his temper, and then riuet this vnto him afterwards, which otherwiſe would bee marred in the fire, and the wide Loope is better then the narrow or the ſtraight plate, and that for two reaſons. The one is, becauſe, as in a Magnet it ſelfe, the force that is in the whole body, ſheweth it ſelfe moſt ſtrongly in his two poles, euen ſo this being a Magneticall body, doth the like in his ends which are his poles: and the ſides of a wide compaſſed Loope (being longer, then of a narrower) of the ſame length, in the *Axis*, muſt needes containe ſo much the more vertue; the other reaſon is, becauſe it ſuppoſeth the flie in his circular motion more equally ballanced then the other: and therefore were it not for ſome other inconueniences, a true circle were beſt of all, which is that except you marke the two places, that you would haue for the North and South, very curiouſly, you ſhall neuer giue him the right touch: yea, very exceeding hardly, although you doe marke them; and alſo the lattin ſtay, that holdeth the capitell, would bee exceeding long and a ſuperfluous burden: but the very beſt forme of all (as I take it) in all reſpects is this, a true circle, hauing his Axis going out beyond the circle, at each end narrow and narrower, vnto a reaſonable ſharpe point, and being

pure

pure steele as the circle it selfe is, haning in the middest, a conuenient receptacle to place the capitell in.

This circle must haue foure very small holes drilled through it, equally distant each from other, for the foure cardinall points, and in both the two poynts, that issue without the circle, being for North and South of equall distance betweene the circle and the end of the poynt two moe, if it be a large one, otherwise one is enough, according vnto this picture following. And this needle is most fit to be vsed for the obseruation of the variation alone without any flie, as I will shew at the latter end of this Treatise.





Whensoeuer you wil set this needle vnto the fly, you must put the capitell through the center of the flie very precisely, and placing the points of the Diameter where you will haue them, thrust little small pins through the vpper face of the flie, and those small holes in the needle, the heads of the pinnes will shew you (if the flie bee larger then your needle) at what poynt your needle standeth, and bowing the body of your pinnes (being thrust through those little holes) close to the card below, will keep it steddy at that place, and from warping also. And so foure pins at the foure cardinall points will serue the turne.

Againe, if you please for to place this needle vpon the vpper face of the Card according vnto *Stevinius*. it is no more but to haue the capitell loose, thrust thorough the center in the bottome of the flie, and the needle placed and fastened on the top, or vpper face of the carde.

But if you will haue a Magneticall needle to serue onely for one size of a flie, the best way is, insteed of the two pinnes in the ends of the *Axis*, to haue a couple of little halfe staples and a *Flower de luce* on one of them, as you see in the Loope, riuetted there. That in turning about the needle, they may still keep the flie close vnto it, and so fasten it with a skrew vpon the capitell whersoeuer you please.

As for his waight it must bee according vnto his largeneſſe, and the waight is one principall cause, that very large compasses are vnprofitable. For the waight of the large carde, and heauy needle, pressing vpon the pinne, will cause the motion of the flie to be dull and vncertaine, and therefore let the past-

board

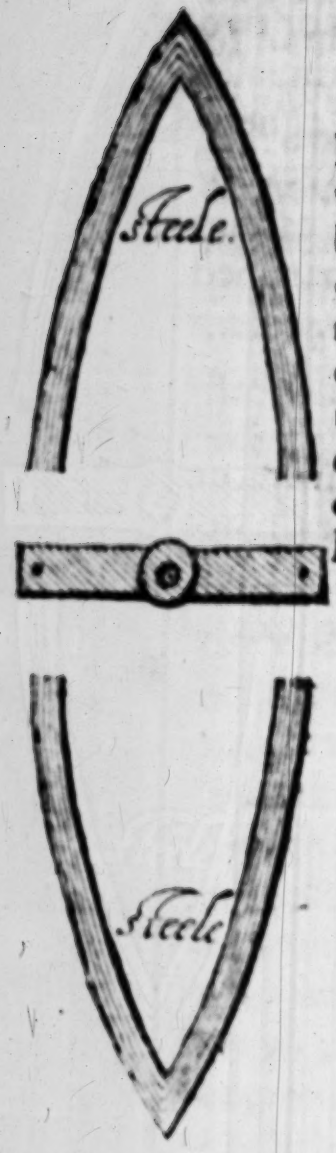
board be no heauier then you muſt needes; and for the ſize of ſixe inches *Diameter* of your paſt-board, and a needle of that length. I know that a needle of halfe an ounce waight, and halfe a quarterne at the vttermoſt (if a good workman haue it in hand) will be very fully ſufficient, of what forme ſoeuer.

The capitell ought to be lattin, and hammer hardned, well and truely boared, not too ſhallow, but of a good conuenient depth and wideneſſe at the bottome, fitting the pinne it ſtandeth vpon at the top. The pinne ought to be either of lattin, or copper, and not of iron or ſteele, as ſome vſe; for they are very ſubiect to ruſt: and the ſteele, eſpecially by long vſe, will weare a little hole in the top of the capitell, and by that meanes the Compaſſe becommeth dull, and they hardly (if euer) will find the reaſon of it; for the hole will bee paſſing ſmall, and entring an exceeding little way in, and yet diſturbeth all. Moreouer, in any wiſe there muſt bee alway an eſpeciall diligent care had of fitneſſe betweene the capitell and the pinne. Oteerwiſe, all things elſe appertaining vnto the compaſſe are nothing worth. This pinne muſt bee very firmely fixed in the iuſt center of the boxe, and the bottome marked, that whenſoeuer you take it off to ſharpen the pin (which vſe will make blunt) you may ſet him in the ſame place againe.

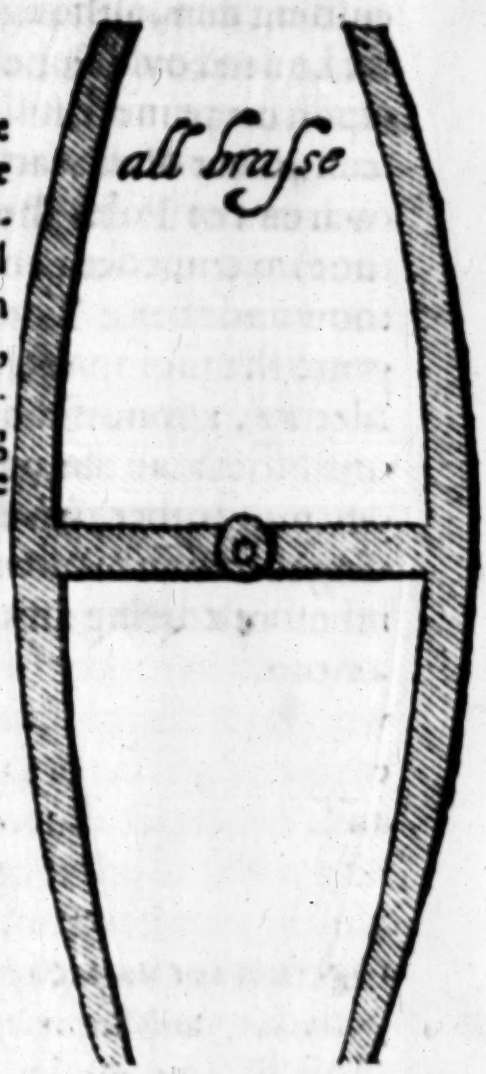
As I haue ſayd that in a Magnet it ſelfe, the vertue is in the whole body, and ſheweth it ſelfe moſt forcible in his poles; euen ſo likewiſe our Compaſſe-needle, being a Magneticall body, ſheweth his force in his ends, which are his poles, although that force doth proceede out of the whole body of the Needle.

Which

Which now I thoght good to make apparant by an euident demonſtration : I cauſed my workeman to make a needle of a Loop faſhion, 8. inches long, or ouall forme in all reſpects fitted to be ſet vnto a ſlie, ſauing that there was but one inch or a little more at each end of ſteele, all the intermediate part between the two ends, being of braſſe: Theſe two ends I did touch with the North and South ends of a very good Magnet : And whereas in a true Magneticall Needle, I ſhould haue had but two points, the one North and the other South, this Mongrell yeelded me ſix, the two ends adioyning vnto the braſſe of contrary natures vnto the ſharpe points, & would no more doe the office of a Magneticall needle then a woodden ſticke, becauſe the vertue was not in the whole, and ſo communicated vnto the two ends, but each end was a totall of himſelfe, being ſeparated, and (as it were) diuorced, the one from all community with the other by that intermediate braſſe : the which being taken away, and the two forkes ioyned together for that length, preſently they became one perfect true Magneticall Needle, and the vertue of thoſe foure confuſed points, which ere while was was loſt in the forkes, will preſently bee found in the two ſharpe ends, and now his naturall ſeats :



Both theſe ends of ſteele were faſtened vnto the braſſe, and then that needle had no Magnericall motion; but being taken off, and ioyned together, they preſently (without any further touching of them) became a true Magneticall Needle.



To conclude this chapter of the Compaſſe-needle, The needle that is ſtill working vpon his pinne continually will keepe his force better, then that which is otherwiſe layd vp, although there bee no doubt of the other, for a mans whole age, or longer, if it be of good mettall, and kept from open aire and ruſt, and from too neere vicinity of iron, but eſpecially of any

Loadſtone

Loadſtone. No better keeping from ruſt, then by varniſhing him, although it be but with a drop or two of Linſeed oyle alone; the needle that is continually vpon his pinne, is ſtill ſtrengthened by the Magneticall power of the earth, ſetting himſelfe alwayes towards the Poles thereof (which the other cannot doe) and needeth onely to haue his pinne ſharpned now and then: The which of all the faults incident vnto the Compaſſe, is moſt eaſily and ſafely amended. And yet, if it bee not very well looked vnto, it diſturbeth all the operation of the Compaſſe more then any other. And diuers wrong themſelues in being too buſie in often touching of their Compaſſes, the fault being in this which no touching can amend.

CHAP. XI.

A Sayling Compaſſe fitted for obſerning at Sea the variation, amplitude of either ſunne or ſtarres, capes or trendings, &c.

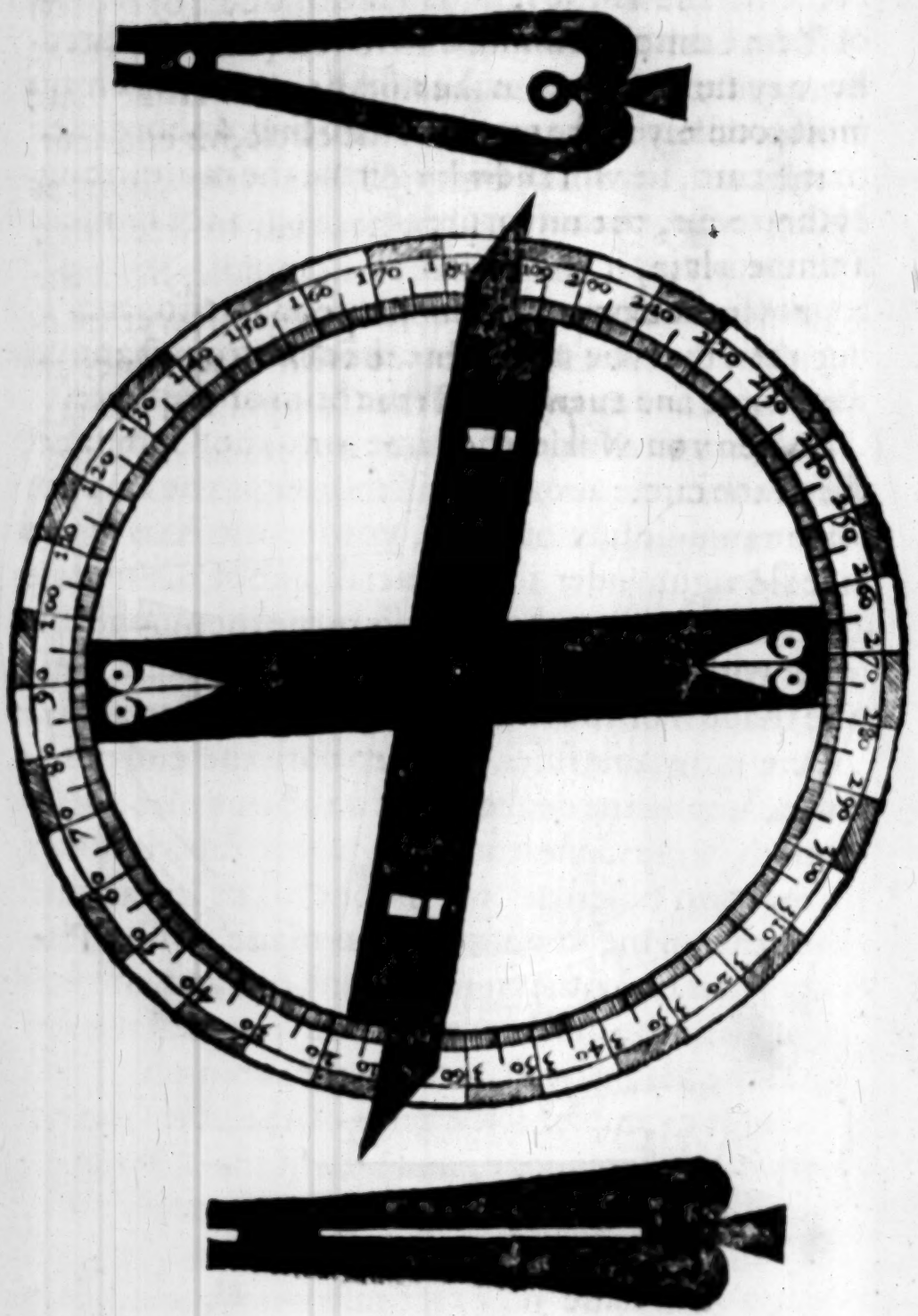
I Haue thought good to conclude this ſhort Treatiſe of Magneticall aduertiſements, with a little additament vnto the ordinary ſayling Compaſſe, fitting him thereby to bee anſwerable vnto the title heere prefixed, as alſo with a compariſon of the ſeuerall vſes, of the Horizontall and inclinatory needles: Let the glaſſe of the inner boxe of the Compaſſe bee of good thickneſſe and ſtrength (but yet

cleere) and euen, thoſe that come from *Venice* for looking glaſſes before the foile be ſet on are the beſt, if a man may haue them large enough. Let this glaſſe be very well fitted vnto the boxe, and ſimmond vnderneath vpon the ſhouldring that beareth vp the glaſſe, with a mixture of waxe, turpentine, ſallet oile and roſin mingled together: or with any other ſimmon as you ſhall thinke good, aboue vpon the glaſſe let there be a ring of thin paſtboard, of the bredth of the ſhouldring vnderneath, in like manner ſimmoned on: then muſt you haue a circle of lattin about the bredth of the paſtboard ring, of conuenient thicknesſe for ſtrength: which muſt bee diuided into degrees: This circle muſt haue a plate of latten, of halfe an inch broad or broader, according vnto the largeneſſe of the circle for ſtrength, that muſt croſſe ouer the middeſt of the circle, cut out of the ſame place with the circle, or elſe ſoadered with ſiluer ſoader: this muſt haue a line all along the middeſt of it, and a little loope at each end cut through the two ends of the loopes being preciſely in that line. Laſt of all, you muſt haue a moueable ruler with two long folding ſights, of about the length of the *Semidiameter* of the circle in bredth about halfe an inch: the one of them muſt haue a ſlit through the length thereof, of about a quarter of an inch broad, as you ſhall thinke conuenient, and two little holes, the one in the top, and the other in the bottome, iuſt in the middle of it, to faſten a ſtring, hauing a very little bead to ſlide vp and downe vpon it. And this ſight muſt be of the thicker ſtuffe then the other. For otherwiſe, becauſe of that which is cut out, it would

be

be ouerpaiſed by the other, and ſo the boxe would ſwarue towards the other; and the ſights muſt each of them haue a little notch in the middeſt of the top of them: this ruler muſt be faſtened (but yet ſo that he may turne about) in the middle of the croſſe plate moſt preciſely in the center of the circle, his ends cut, that he may ſhew the Fiduciall line in the diuiſions of the circle, the other ſight needeth to bee but a a plaine plate, hauing a line in the middle, from the top to the bottome. The deſcription followeth, being the very ſame in ſubſtance with that, which in the *Nauigators Supply*, I call the Compaſſe of variation; although all things eaſier performed with this, then with that,

The Picture.



The Vses.

The Compasse being thus fitted, place the circular needle described in the sixth chapter, vpon his pin alone without any flie. For being disburdened of the card, he will shew his vertue the more strongly, and being of that forme he will ballance himselfe sufficiently.

Place the circle vpon the glasse and pastboard, in such sort that you may turne the circle round about, very close and euen, within the brim of the boxe.

When you will set the same vnto the Compasse, turne the circle about, vntill thorough the Loopes of the middle stay or plate, you see the Axis of the needle right vnder the Fiduciall line of the middle stay, then holding the circle so, turne the moueable ruler with the stringed light towards the sunne, vntill the shadow of the string fall vpon the fiduciall line of the moueable ruler, for then doth the end of the ruler, among the degrees, shew the true place or Azimuth of the sunne from the Magneticall Meridian, so that two obseruations, the one in the forenoone, the other in the afternoone, thus made, with the seuerall heights of the Sunne, being one and the very same, halfe the differences of those places of the sun, from the Magneticall needle is the variation.

As for example, if the ends of the ruler did cut forty in the forenoone, and fifty in the afternoone, the difference is then, the halfe therof fiue: so much must the variation be Westward.

If a man haue no exact instrument to take the heighe

height of the ſunne, hee may make ſome reaſonable ſhift, by ſetting the little bead towards the top of the ſtring, that it may in the forenoone caſt a ſhadow vpon the Fiduciall line of the ruler; and marking that place with any thiug (as inke or blacke lead) in the afternoone attend, vntill the ſhadow of the bead (the bead remaining ſtill where it was) fall vpon that place. For then ſhall you haue that ſame height, if you will take the amplitude of the ſuns riſing or ſetting, ſet the circle, and turne the ruler, as before, vntill the ſhadow of the ſtring do fall vpon the middle line of the other ſight. Then doth the end of the ruler ſhew, how farre the ſunne riſeth or ſetteth from the magneticall Meridian.

When you will take the amplitude of the riſing or ſetting of any ſtarre, you muſt vſe the helpe of another, to holde the circle ouer the needle (as before) and ſo you turning the ruler, vntill you ſee the ſtarre in his riſing or ſetting, through the two Notches on the tops of the ſights, then doth the end of the ruler ſhew your deſire, The like is to be done in obſeruing any cape, or the trendings of any land for the dedeſcription of any Coaſt.

Chap. XII.

A compariſon of the ſeuerall vſes of the Horizontall and inclinatory Magneticall Needles.

THe Horizontall and inclinatory motions of Magneticall needles are both of them but one

and

and the selfe same effect of the *Magnet* or *Loadstone*, the making of the Horizontall or Diall-needle, is among our artificers very well known and triuiall, only they are to be put in minde that they doe alwaies make them of pure steele and not of iron. But as for the making of the inclinatory needles, it is a very curious peece of worke: It must be of pure steele, and in his right temper, the needle and his axis must bee at right angles the one with the other, and must bee so hanged on the two ends of his axis that hee bee very pliant for his motion, and that (before he haue his touch) he bee so equally ballanced, that the one end be not one iot heauier then the other, for if it be, all the rest is in vaine.

When you will vse the inclinatory instrument, thus you must doe, hanging him by his little ring, turne him about vntill hee make his least declination (or inclination) vnder the Horizon of the instrument: for then is hee iust in his Magneticall Meridian, and there sheweth his due poynt, the which otherwise he can neuer do. But here I must admonish you of two very great errors published in the contriuing of this noble instrument. The one is, that he would haue a little box with an Horizontall Needle fastened vnto the bottome of the inclinatory instrument: for to direct the instrument vnto the Magneticall Meridian: and by his picture of the Instrument, the distance should be but a little more then an inch, where it is impossible but that the one needle must needes disturbe the other, so that neither of them can shew aright, yea, although they were six inches asunder, and more, where the little box will giue little

direction for that purpose: and besides that, it is altogether vnnecessary, because the instrument will finde the Magneticall Meridian, by the least declination of the needle (as is shewed before) vnder the Horizon, without the helpe of any other. The other error is this, that he would haue that end of the needle prepared to hang towards the North, to bee framed somewhat higher then the other, as is vsuall in Horizontall needles: what workman soeuer obserueth this direction, I will assure him, that hee shall lose his labour, and assoone hee may wash a Blackemoore white, as to make such a needle serue that turne. The reason is, because it is onely the magneticall vertue that worketh this effect, the which ouerwaight, in either end of the needle (in this motion) doth vtterly ouerthrow.

For Horizontall needles in our Northerne Climates, it is necessary: but for inclinatory needles, it is vtterly vntrue in all Climates of the whole world whersoeuer. The motion of the Horizontall needle, is naturally stronger then the inclinatory for two causes, The one is because his motion is onely sidewaies, the which is easier for the Magneticall motion to worke in, then that which is vp and downe, and that there is no difference which way you place the boxe wherein he standeth, so that it bee paralell vnto the Horizon; whereas the inclinatory motion is in a verticall circle vp and downe, and must stand onely in his Magneticall Meridian to performe his office. The other cause is because of the diuersity of their placing in their boxes: for the Horizontal needle standeth more fitter for his motion, being placed with

with his capitell vpon the poynt of his sharpe pinne, than the inclinatory can doe, being placed vpon the two ends of his axis, although neuer so neere the poynts: But yet he will doe very well, if he be rightly fitted: And for Nauigation vnder either Pole (if there be any passage that way) it is the onely Instrument of the world. For where the Horizontall needle (or compasse) faileth, he is strongest, for the neerer the Pole, the stronger he is in his Motion, contrariwise, it is with the Horizontall needle or compasse, for he is strongest at the *Æquinoctial*, and of no force vnder the Pole.

The reason whereof is this, vnder the *Æquinoctiall* the Horizontall needle standeth paralell vnto the *Axis* of the earth, and is equally strengthened for his motion with the two poles of the earth: but vnder the poles, hee standeth crosse-wise, at right angles with the *Axis*, his center representing the very pole of the earth it selfe; so that the *Æquinoctiall*, and the Horizon being there all one, if the needle should haue any Horizontall motion there, it must needes be an East or West motion paralell vnto the *Æquinoctiall*, directly contrary vnto nature, and to all Magneticall doctrine.

Yet at the pole, the inclinatory needle is in his cheefest strength, framing himselfe to bee in the same direct line with the *Axis* of the earth it selfe: so that the vicinity of the neerest pole of the earth, holdeth his conuenient end of the needle most strongly, being nothing at all hindered by the aduerse pole, to affect the vpper (or other) end of the needle. The which in all other scituations either more or lesse it

doth, and especially vnder the *Æquinoctiall*, where each pole affecting his conuenient end of the inclinatory needle, it must stand very goglingly and vnsteddily for that motion: although most strongly for the Horizontall, if you place him accordingly.

Where hence it followeth, that neere the *Æquinoctiall* large compasses, and small inclinatories are fittest; and neere the poles large inclinatories, and small compasses are best, for looke vnto what motion the Magneticall force is weakest, the smaller instruments ought for to be applied.

And moreouer, forasmuch as the Magneticall reuolution of the inclinatory needle, about the globe of the earth maketh his motion for the difference of euery alteration of Latitude neere vnto the *Æquinoctiall*, farre more large & easier to be discerned, then it can be neere the poles, therefore a lesse Instrument will serue the turne there: And because that neere the pole, his motion for differences of Latitudes are exceeding small, and hard to be discerned. Therefore very large instruments inclinatory are there to bee vsed, especially because the Magneticall strength of the needle for that motion, is there so strong and steddy, that it maketh som recompence for the slowuesse of his moouing. And therefore I suppose that three in Diameter, will serue neere the *Æquinoctiall*, and fifteene neere the *Pole*.

And because this great one may be the lesse cumbersome, you may cut off the circle at forty and fiue degrees of each side of the *Zenith* and *Nadir* of the Instruments, and yet leaue the needle scope enough, for all Latitudes between sixty *Degrees* and the *Pole*:

and

and for the the ſteddy ſtanding of the inclinatory inſtrument at the ſea, you may doe thus: about the middle of the inſtrument (or rather ſomwhat aboue the middle) let there be two round pins of braſſe, about three quarters of an inch long, iſſue out; and in a box of a ſayling Compaſſe, the inner circle being taken away, make of each ſide two halfe round notches in the outer circle, there place the Inſtrument vpon thoſe two pins, the which muſt haue towards their ends, littles circles cut in, that they ſlip not out of their rings that they are placed in: then will this Inſtrument ſtand as ſteddy, euen at ſea, as the ſayling compaſſe will doe: for the motion of the inner circle is performed by the turning of thoſe two pins in their notches, and the outer circle is common vnto them both, alwaies remembring that you hang ſome ptetty waight in the bottome of the inſtrument, to make his motion more certaine: If the ſhaddowing of the box hinder your ſight from diſcerning the point, that the needle ſtandeth at, it is ſoon holpen with the light of a little waxe candle put downe vnto it: and yet this you ought to vnderſtand as aforeſayd, that the Hotizontal and inclinatory motions are but one and the ſelfe ſame effect of the touch of the Loadſtone, and one and the ſelfe ſame needle will very well performe both motions, namely, the inclinatory needle, not the Hotizontall, becauſe his placing vpon the pinne maketh him very vnfit for the inclining motion. But the inclinatory needle reſting with one poynt of his *Axis* (the poynts of his *Axis* being very ſharpe) in his little hole, his boxe being placed paralell vnto the Horizon, will performe the Horizontall motion very well. For being placed with the ſharp

point of his *axis* in that hole, it is all one in effect, as the Horizontal is with his capitel on the ſharp point of his pin, but that the one is vpward and the other downward,& yet either of them being as fit for that motion, as the other. Vpon the conſideration hereof, my workman of Wincheſter minding to preſent *Prince Henry* with a rare Inſtrument, contriued an *Aequinoctiall Diall* & an Inclinatory Inſtrument both in one, and one needle to ſerue very well both thoſe turnes. Heerein now appeareth the wonderfull wiſdome of our God, in limitting his times and ſeaſons for the reuealing of theſe wonderfull properties for the vſe of men, in this poore ſtone; namely that aboue 2000. yeeres after that it was knowen and wondred at in the world, for lifting vp of iron (for it was an antiquity in *Platoes* time) the vſe of the Horizontall needle was known, in common vſe, ſcant 200. yeeres agone; and very few yeeres ſince (yea ſcant as yet) the inclinatory is in any common vſe: and who is there that can behold and conſider both theſe vſes, *viz.* both to ſhew the quarters of the world (as *Eaſt*, *Weſt*, *North* and *South*, *&c.*) and alſo the Latitude of the place: to know both theſe in any place of the world, bee the heauens neuer ſo much ouercaſt with clowds, who is he, I ſay, that can beholde theſe two admirable and precious vſes performed, euen with the turning of an hand, the which neither the Grecian Philoſophers, nor the fine-witted Romans, nor the Perſian Magi, nor the Indian Gymnoſophiſts could finde out with all their skill and cunning, but he muſt needs ſay with that Kingly Prophet, *O Lord, our Lord, how great is thy name through all the Earth, who haſt ſet thy glory aboue the Heauens?*

To

To the Worshipfull my good friend, Mr. *William Barlow* at Easton by Winchester.

REcommendations with many thanks for all your paines and courtesies, for your diligence and enquiring, and finding diuers good secrets, I pray proceede with double capping your Loadstone you speake of, I shall bee glad to see you, as you write, as any man. I will haue any leisure, if it were a moneth, to conferre with you, you haue shewed mee more, and brought more light than any man hath done. Sir, I will commend you to my L. of Effingham, *there is heere a wise learned man, a Secretary of* Venice, *he came sent by that State, and was honourably receiued by her Maiesty, he brought me a lattin letter from a Gentle-man of* Venice *that is very well learned, whose name is* Iohannes Franciscus Sagredus, *he is a great Magneticall man, and writeth that hee hath conferred with diuers learned men of* Venice, *and with the Readers of* Padua, *and reporteth wonderfull*

derfull liking of my booke, you ſhall haue a coppy of the letter: Sir, I purpoſe to adioyne an appendix of ſix or eight ſheets of paper to my booke after a while, I am in hand with it of ſome new inuentions, and I would haue ſome of your experiments, in your name and inuention put into it, if you pleaſe, that you may be knowen for an augmenter of that act. So for this time in haſte I take my leaue the xiiijth of February,

Your very louing friend,

W. Gilbert.

Faults escaped.

IN the Preface speaking of Claudianus: *sereditical* for *sideritical*. fol. 12. lin. 22. *reciprocated* for *riciprocally*. fol. 50. lin. 21. *hangings* for *hugenes*. fol. 53. lin. 16. *as may be*, for *as many be*. fol. 57. lin. 10. *but this is not*: for *this is not*. fol. 68. lin. 19. *suppoſeth the fly*, for *ſupporteth the fly*. fol: 79. lin. 11. *ſet the ſame*: for *ſet the Sunne*, item lin. 27. *the difference is then*: for, *the difference is ten*. fol. 82. lin. 8. *higher*: for, *henier*. fol. 84. lin. 26. *three in Diameter*: for, *three inches in Diameter*. fol. 85. lin. 10. *littles circles*: for, *little circles*. The laſt line ſaue one of D. Gilberts letter, *all*: for, *arte*.